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THE WATER PROBLEM IN GREAT BRITAIN

WITH many reservoirs in Britain half empty as a result of the summer drought and its prolongation into the autumn, concern is once again being expressed about the water resources of the country. It is not easy for the general public to reconcile restrictions and appeals for constraint with periods of apparently normal rainfall, and yet this frequently occurs. Even to the layman, there is clearly something amiss when water conservation forces an interruption of supplies in normally wet localities such as Durham. These are but the first portents of a problem which shows every sign of becoming more acute with the passage of time.

The total amount of water supplied by water undertakings in England and Wales at present is estimated to be in the region of 1,750 million gallons a day, or an average of some 40 gallons per head of the population. This amount has been steadily rising during the past two decades, and it has been estimated that the water undertakings will be called upon to supply in fifteen years time at least twice the amount consumed in 1938. This rapidly rising rate of consumption is partly connected with the increased population and its rising standard of living; but water requirements are increasing much faster than the growth of population. Improved sanitation and hygiene and the shift from rural or urban areas account for much; but it is the spectacular consumption in the industrial field which calls for most comment. Increasingly formidable demands are being made by industry.

For example, it is estimated that the refining of one barrel of crude oil requires eighteen barrels of water, the production of a ton of steel needs 65,000 gallons of water, a ton of sulphite paper similarly needs 64,000 gallons, the processing of a gallon of alcohol requires 100 gallons of water; while the demands of thermal generating stations and atomic power stations begin to look astronomical—some 80 gallons are needed for each kWh. produced. At the same time, numerous industrial establishments discharge waste of many kinds such as acids, oils, chemicals, etc., which pollute the streams because of their poisonous, harmful or offensive effect. Cooling water returned to streams at high temperature further complicates the supply for cities and industries downstream. The problem is, of course, by no means confined to Great Britain. Even in the United States the industrial use of water has exceeded the agricultural use, and the Paley Commission has estimated that by 1975 industry will be consuming two-thirds of all available sweet water, and that availability of water will be the main factor in determining the location of industry.

Agricultural demands in Great Britain may shortly aggravate the problem still further. The possibility of controlled growth of crops and grass by summer irrigation (already demonstrated by successful experiments at Rothamsted Experimental Station) involves exceptional demands for water. In south-east England in a dry summer, up to 250,000 gallons per acre could be usefully applied.

While Nature is fairly bountiful in her supply of water to the British Isles—it is estimated that in a year of average rainfall some 2,000 gallons of water per head per day descends upon us—the greater part is 'lost' in sustaining river-flows to the sea, and this water returns fairly rapidly to its source. As the river-volume is often irregular and intermittent, or locally insufficient, water must be stored or conserved. Britain has no glacial ice-cap to store winter precipitation against summer demands and drought, and we must depend on reservoir storage overground and natural storage underground. The water storage capacity of England and Wales overground is now of the order of 200,000 million gallons, which provides these areas with about three months supply of water. But although this is regarded as sufficient insurance at present against there occurring not more than once in ten years a drought as long as the longest known drought, the insurance is not evenly spread throughout the country; and, in fact, most parts of Britain need to restrict supplies of water if no measurable rain falls for periods in excess of about thirty days. Moreover, this reserve does not take into account the steadily increasing demands.

The natural storage underground of water is largely confined to certain receptive geological formations, notably the chalk. This has a surface outcrop in Britain of some 5,000 square miles which, catching an average of some 20 inches of rain a year, gives an annual yield potential of some 750,000 million gallons. Other important aquifiers are the Midland Oolites, covering 2,000 square miles, with a yield potential of 315,000 million gallons yearly; and the Triassic sandstones, covering 1,750 square miles, with a yield potential of 300,000 million gallons yearly. With 15 per cent of our present consumption derived from underground sources, these figures appear reassuring, until we realize that widespread boring and pumping would be necessary to tap all the available resources, which again are not always in the right places. Furthermore, the utilization of these supplies needs careful management. Reports of falling water-tables from nearly all areas using ground-water are commonplace and indicate a rate of extraction in excess of replenishment. Present withdrawals for the 10 million inhabitants of the London Basin take some 260 million gallons daily from the chalk: records show a steady fall in the water-table here for the past hundred years. In the Thames Estuary the hydrostatic level is now several hundred feet below sea-level, and the seepage of brackish water is causing concern. The Water Act of 1945 now forbids the boring of further wells in the City of London without a licence from the Ministry of Housing and Local Government.

The total water supply in Great Britain is clearly adequate; but it is of little use unless it is available in the right place at the right time. Nature unfortunately distributes it very unevenly in both time and space. How are we to escape from this dilemma? Clearly more water could be impounded in reservoirs; but there is an obvious economic limit to this process,

for it consumes much-needed land and disturbs many interests. There is the possibility of a much higher standard of watershed management to hold back the run-off and so conserve supplies. Artificial recharge of underground sources now suffering depletion could also be practised, as in the United States and the Netherlands. In the London Basin, some 150,000 million gallons of the Thames flow might be preserved in this way. The use of sea water is also possible where salinity is no objection, although this produces problems of corrosion in pipes. The desalting of ocean water as well as cloud seeding to induce rainfall are probably as yet uneconomic.

The idea of a national water grid for Britain has occasionally been mooted, and indeed found a place in the Labour Party's election manifesto of 1950. But water, although an equally important public utility, is not like gas or electricity : it largely depends on gravity for natural movement, and many doubts have been cast upon the economic and engineering feasibility of a national water grid. At the present time, there are some 1,100 water undertakings in England and Wales responsible for providing public supplies. More than 900 are local authority organizations, some 115 are statutory water companies, 54 joint water boards and 47 smaller non-statutory water companies. There has been a tendency for smaller water authorities to be absorbed by the larger and for joint boards to be formed ; but there is still a great number of separate undertakings. In addition to these public supply authorities, there are innumerable private water developers : for example, in the City of London more than a hundred 'wells' supply office and industrial buildings. There is thus a great multiplicity of water undertakers all working independently and very often against each other ; and the problem which is looming ahead is being nibbled at piecemeal all over the country.

There thus seems strong grounds for an over-all national water policy, and this was, in fact, envisaged in the Water Act of 1945, which imposed upon the Minister of Health the duty, since transferred to the Minister of Housing and Local Government, "to promote the conservation and proper use of water resources and the provision of water supplies in England and Wales, and to secure the effective execution by water undertakers, under his control and direction, of a national policy relating to water". The necessary administrative organization to achieve this has, however, been slow to emerge, and many complaints have been voiced. The Minister did not set up the regional advisory committees which the Water Act empowered him to appoint. The River Boards Act of 1948 set up boards responsible to the Minister of Agriculture. The Central Advisory Water Committee lapsed in 1952, and the Inland Water Survey was suspended as an economy measure in the same year (see *Nature*, November 7, p. 823, 1953 ; and *The Times*, March 24, 1954) ; and the industry has complained that it has been allowed too little capital investment in comparison with other national utilities. (Manchester's Haweswater Reservoir, which was completed in 1941, had not been tapped by 1949 because of restrictions.)

The water industry has proposed the formation of a 'Water Commission' separate from, but appointed by and answerable to, the Minister of Housing and Local Government. This idea has been formally submitted to the Ministry by the British Waterworks Association, but appears to have found little favour. Since this action the United Nations Economic and Social Council, in a report on Development and Utilization of Water Resources (London : U.N. Information Centre, 1954), has recommended "that each country would be well advised to set up a water board or water commission at cabinet level". It is envisaged that such a water board would have representatives of all interested government departments and local government bodies concerned with the numerous aspects of water conservation and utilization. The problem of supply could be looked at as a whole and suitable policies formulated. The need clearly exists in Great Britain, as elsewhere, and the recent decision of the Minister of Housing and Local Government to revive and reconstitute the Central Advisory Water Committee is a welcome step in the right direction (*Nature*, October 22, p. 768, and November 12, p. 908). This Committee is now to consider the extent to which the demand for water is likely to increase and also the ways and means of collecting hydrological data, and will then make recommendations. Its report will be awaited with interest, for this problem is closely related to that of flood control, which, as has already been emphasized in these columns (*Nature*, 172, 263 and 823 ; 1953), also merits more detailed attention. Without much careful thought and more vigorous action, we must inevitably move in the future into the paradoxical situation of increasing water shortages amid plentiful precipitation and recurrent flooding.

THE THREAT TO SCIENCE

A STRIKING picture of the dangers which confront men of science has been prepared recently by Gerard Piel, publisher of *Scientific American*, one of America's leading magazines (*Bull. Atomic Scientists*, 11, No. 7 ; September 1955). At the outbreak of the Second World War, he writes, science was a kind of ideal world republic. The scientific community was an international community. It was the only truly international community at an epoch that was to see nationalism and the narrower concerns of national power rise again to ascendancy in world politics.

Statesmen discovered early in the War that science is an essential element of national strength. To-day they rank it as equal in importance to their industrial and military establishments. Accordingly, each major power has sought to monopolize the talents of its scientists and to put them to work in the name of national security. This suppression of international motives in favour of national ends has now had serious consequences upon the life of science. The situation in the United States provides an extreme case of what, to a greater or lesser degree, has been happening in other nations.

Scientists are agreed, in the first place, that there has been a dangerous diversion of resources and talent from the really significant long-range concerns of science to the narrower short-range objectives of practical results. Nearly half America's expenditure each year goes to armaments. Economic and social pressures have moved a disproportionate percentage of the inadequate supply of scientists from universities to government and industrial laboratories. Even in American universities, the work of science has become dependent upon income from outside contracts and subject to the outside motivations which such contracts imply. As a result, the careers of an alarming number of the younger generation of scientists are now permanently lost to science. The education of the next generation is jeopardized by the breakdown of science teaching in American high schools and colleges. The future of science has been mortgaged in the eagerness to exploit its past.

Science has come under another kind of duress through preoccupation with national security in the narrow and negative technical sense of the term. Military secrecy seriously hampers publication and communication in a number of major fields of work. Direct contact between scientists has been disrupted by restriction on the travel of American scientists abroad and the admission of foreign scientists to America. Scientists have been among the most notable victims of the invasion and abuse of personal privacy and dignity which characterize the loyalty and security programme of the Federal Government. Outside any conceivable connexion to national security, the attendant obsession with loyalty has created an atmosphere of fear and conformity which is as obnoxious and stifling to science as to any other branch of free inquiry.

It is impossible to calculate the damage that has been done to the integrity and vitality of the American scientific establishment. "Without doubt we shall pay for it in the future. It will show up in the loss of the advances in technology which should have come from the progress in science we have set aside today."

There is a lesson in this recital. The scientific enterprise cannot be successfully subordinated to merely national ends. Without the long view—the world view—the advance of science must falter and come at last to a halt.

The international tradition runs too deep in the life of science, however, to have been throttled in fifteen years. Among scientists in every field, their personal and professional associations with colleagues abroad, their mutual respect for one another, and the sharing of achievement in significant work establish bonds which outreach the dividing movements of this period. The international community of science still provides us with our most hopeful example of a world polity, in which statesmen and citizens as well as scientists may some day participate.

In the rest of his article Piel points to activities like the International Geophysical Year and the work of the United Nations Technical Agencies as examples of those forces which should serve as hope and encouragement to men of science everywhere.

MODERN CYTOLOGY

International Review of Cytology

Edited by G. H. Bourne and J. F. Danielli. Vol. 4. Pp. xii+419. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1955.) 9 dollars.

As usual, Dr. G. H. Bourne and Prof. J. F. Danielli have selected widely different topics for Vol. 4 of the "International Review of Cytology". While many readers might well ask for more unity, I thoroughly enjoy this non-conformist lack of uniformity. The articles in which I am directly interested are extremely useful and valuable for my research work; the others are no less important for a teacher in general biology.

The first paper, by M. J. Kopac, deals with cytochemical surgery: the list of the methods and the instruments available for quantitative cytochemical investigations on isolated cells or their parts is very complete; but the descriptions are somewhat too short to enable one to utilize them without going back to the original papers. A new "volumetric submicromanipulator" and a modified microdilatometric method are described; they should prove useful, but it is perhaps unfortunate that the results obtained so far with them—if there are any—are not mentioned.

After an interesting article on amœbocytes, especially in molluscs, by L. E. Wagge, M. Wolman discusses cytological and cytochemical fixations: the expected conclusion is that even freeze-drying is far from ideal and that there are no good universal fixing-agents. The next two papers, by A. Marshak and by R. Vendrely, deal respectively with bacterial cytology and histochemistry (the latter a rather ill-chosen title, since bacteria scarcely constitute a tissue in the usual sense). They are well documented, but their very carefulness leaves the reader with a slight feeling of frustration; he will often have to draw his own conclusions.

Next come reviews on plant mitochondria (D. P. Hackett) and the structure of chloroplasts (K. Mühlethaler); we are here on safer ground, and there seems to be little reason to doubt that plant mitochondria strongly resemble animal mitochondria, and that the structurally complex chloroplasts originate from proplastids distinct from the mitochondria. N. B. Kurnick's review on the histochemistry of nucleic acids is very thorough and critical; although it only deals with the techniques, it should prove very useful.

The article on structure and chemistry of nucleoli, by W. S. Vincent, is clear and contains much new information; the author reaches the conclusion that the nucleolus might be the site of a limiting rate-reaction necessary for the maintenance of cytoplasmic syntheses. With H. Moe and R. Couteaux the reader comes back to more orthodox cytology: the former writes about goblet cells, the latter about the localization of cholinesterase at neuromuscular junctions. Both papers are very well illustrated. Finally, E. J. Conway surveys the evidence in favour of a redox pump in the active transport of cations, and shows that this hypothesis adequately explains many facts in yeast cells as well as frog skin, gastric mucosa or plants.

The book is very well produced; the unfortunate consequence is its rather high price. There are extremely few misprints—usually names of authors quoted in the text or in the bibliography; but why is it that the only two words quoted in French are wrongly spelt?

J. Brachet

STRATIGRAPHICAL PALÆONTOLOGY

Stratigraphical Palæontology

A Study of Ancient Life-Provinces. By Dr. E. Neaverson. Second edition, revised and enlarged. Pp. xii+806+18 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1955.) 105*s.* net.

THIS second edition of Dr. E. Neaverson's text-book has been awaited with much interest. The earlier filled a gap of which teachers of palæontology were well aware. It was the first attempt at producing, in Britain, a book dealing with the application of palæontology to stratigraphy, and giving a general account of the succession of faunas and floras throughout the Earth's history. The remaining stocks of this book were destroyed towards the end of the Second World War as a result of enemy action, and the author, in preparing a second edition to make good this loss, has taken the opportunity of revising and augmenting the original. The chapter dealing with the morphology of fossils, more appropriate to a text-book of general palæontology, has been omitted. On the other hand, the account of the marine faunas has been usefully augmented to include details of their occurrences outside Britain. Three more chapters have been added to deal with the vertebrate land faunas of the several continents, and in a final chapter the relationships of the continents as revealed by their past faunas are discussed.

Dr. Neaverson has gathered together a vast amount of information from numerous and scattered sources to make a book which should be invaluable to teachers, no less than students, of stratigraphy. Unfortunately, it is now in size and cost more of a book of reference than a text-book that every student could be expected to buy. The emphasis is on the zoo-geographical aspect in that the faunas are discussed *seriatim* under the various systems so that evolutionary changes are difficult to follow. Since stratigraphical subdivisions are largely based on such changes, a clearer picture of the dependence of stratigraphy on palæontology might have been given if the history of each phylum in turn had been traced throughout the geological record. This treatment has, in fact, been partly accorded to the fossil plants, the account of which is oddly placed in the middle of the book between "Carboniferous Faunas" and "Tetrapod Faunas of the Late Palæozoic System".

The accounts of the faunas of each system are comprehensive and well documented. They assume in the reader a fairly high standard of stratigraphical and palæontological knowledge, but could have been made much easier to digest by the provision of good palæogeographical maps in place of the numerous peculiar and not very informative maps on which the distribution of rocks is shown by crosses, circles and black disks.

In these days, when the economic aspect of geology is more important than ever before, it is to be regretted that Dr. Neaverson, in common with many other teachers of palæontology, has paid so little regard to the microfossils. Less than a page is devoted to the Ostracoda. The larger Foraminifera are paid a little more attention, but no indication is given that there are large and varied microfaunas in almost every formation since the Cambrian, some of which are used daily as guides to stratigraphy. The last chapter, on the relationships of continents and oceans, is interesting in its treatment of a complex and difficult subject but would, nevertheless, have been better omitted. The subject is perforce dealt with too superficially, and the evidence is not discussed entirely without bias.

The book is well indexed and includes eighteen excellent plates figuring a number of fossil species, though the selection is a little unbalanced: one plate is devoted to nummulites, three to brachiopods, no less than eleven to the cephalopods, one to lamellibranchs and two to echinoids. F. W. Anderson

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MATHEMATICS FOR BIOLOGISTS

Biomathematics

The Principles of Mathematics for Students of Biological Science. By Dr. Cedric A. B. Smith. (Being the Third Edition and a rewritten version of the work by the late W. M. Feldman, M.D.) Pp. xv+712. (London: Charles Griffin and Co., Ltd., 1954.) 80*s.* net.

NEARLY eighty years ago Charles Darwin described in his autobiography how the study of mathematics had been repugnant to him in his early days, and then went on to deplore his consequent lack of understanding of mathematical principles, adding in explanation, "for men thus endowed seem to have an extra sense". How often must Darwin's words have been echoed by biologists, especially with the tremendous increase of quantitative treatment in biology during the past thirty years or so. This great trend towards the quantitative has been most striking in the laying out of experiments and the interpretation of results; but it is to be seen also, and no less characteristically, in the growing use of mathematics for the development of biological theory. Biologists are in fact being faced with an increasingly insistent demand for capacity, as well as willingness, to utilize the tools which mathematics offers. Willy-nilly they will have to be prepared, in growing numbers, to acquire and use at least some mathematical skill; and they will need books to help them to do so.

There is now no shortage of books dealing at a variety of levels with mathematical aspects of the acquisition, analysis and interpretation of biological data; but Dr. C. A. B. Smith has set out to meet a different need. In rewriting "Biomathematics" he has followed the late W. M. Feldman, to whom the two earlier editions were due, in aiming at a presentation of the fundamentals of mathematics as such, so that the biologist should be able to see for himself how his problem can be handled mathematically. Starting with an account of arithmetic procedures, including those appropriate to calculating machines and punched cards, the book goes on to cover a great deal of ground including not only the more familiar principles of algebra and geometry but also inequalities, series, integral as well as differential calculus, vectors, matrices and statistical theory.

By mathematical standards the treatment is doubtless very largely introductory; but the biologist will find here a wealth of notions and methods such as can scarcely have been available to him before within the covers of a single volume. He must not expect to find the going always easy, as Dr. Smith indeed warns his readers on p. 1, and probably few biologists will take the full course of seven hundred pages without some skipping. Some parts, such as, for

example, those dealing with the solution to equations, nomograms and probability, will inevitably be more widely read because they deal with requirements which arise more widely in practice. In fact, although this may not bring out its full value, "Biomathematics" is likely to be used chiefly as a reference book to be dipped into as the need arises, and its use in this way will be all the easier for the glossary of symbols provided at the beginning. The need for such a source of mathematical reference is more widespread than even biologists themselves probably feel.

So long a mathematical book can scarcely fail to be expensive, and it is perhaps an inevitable misfortune that at 80*s*. the price of "Biomathematics" will limit its sale. It is to be hoped, nevertheless, that younger biologists will at least have ready access to Dr. Smith's book in their laboratories, and will be encouraged to use it. For, given the opportunity, it can offer much-needed help. K. MATHER

PRINCIPLES OF ANALYTICAL INORGANIC CHEMISTRY

Grundlagen der analytischen Chemie und der Chemie in wässerigen Systemen

Von Prof. F. Seel. Pp. 348. (Weinheim/Bergstr.: Verlag Chemie, 1955.) 29 D. marks.

THIS book deals in five chapters with the separation of metal ions by precipitation techniques, reactions in molten salts, various volumetric titrations and electrolytic separation methods. In twenty chapters problems of more general interest are set out: namely, definitions and fundamental theories, mass action law, solubilities, theories of precipitation, colloid chemical effects, formation of complexes, proton transfer reactions, acid-base equilibria, ion exchangers and oxidation–reduction processes.

Students who read this book are liable to get an unbalanced view, because the usefulness of the mass action law in dealing with heterogeneous systems is over-emphasized and because many important topics are omitted; for example, the relative contributions of ΔS and ΔH to ΔF of a chemical equilibrium, or an appropriate treatment of reaction kinetics and mechanism. Furthermore, there is no coherent story, the presentation being confusing and not consistent. Thus, the mass action law is derived, *ab initio*, in Chapter 2, while the derivation of Nernst's formula, connecting electromotive force with ionic activities, is only very briefly indicated in an appendix, although it is extensively used in the last ten chapters. There are statements such as "reactions with positive pK values use up energy and reactions with negative pK values yield energy" (pK is the negative logarithm of the equilibrium coefficient), or "the energy of dissociation of certain complexes must be derived from a precipitation reaction". In other sections reactions are classed as "inhibited", although it is not suggested that an inhibitor influences the kinetics, the failure to reach equilibrium within a short time being merely due to the energy or entropy of activation. Again, the term "physical" solubility is introduced, implying that this is different from other solubilities, but there is no definition; and many numerical values of pK are listed, in the text and in four tables of the appendix, without specifying the temperature.

Advanced research workers and university teachers, on the other hand, should not be unduly disturbed by these and similar shortcomings; but this class of readers, if interested in analytical chemistry, will miss a discussion of colorimetric, flame photometric, chromatographic and polarographic methods, and representative literature references.

It must be pointed out, however, that five out of the twenty-five chapters are rather enjoyable to read, provided they are considered as separate short monographs. These chapters contain instructive numerical calculations and some useful information not given in conventional text-books of analytical chemistry. ALBERT WASSERMANN

LENS THEORY

Theory of Lenses

By E. W. H. Selwyn. (Monographs for Students.) Pp. 62. (London: Institute of Physics, 1955.) 5*s*.

BY the theory of lenses, Mr. E. W. H. Selwyn means a discussion, in terms of physical optics, of the behaviour of real lenses. This book is intended for students preparing for the Higher National Certificate in Applied Physics, and is one of a series bridging the gap between the elementary text-books and the academic and technical treatises. Its outlook is original and refreshing, and the author's long experience of both lenses and learners has enabled him to deal handsomely by both. His aim, he says, is that the reader shall not be too much surprised by some of the things he may notice when using optical devices or trying to make them in the laboratory. One feels that the student who has fully mastered the contents of these few pages will really understand what he is doing in such circumstances, for this is an excellent introduction with a very practical approach.

After an initial discussion of the wave theory of light, in which the beginner's difficulties with Huygens's construction are admirably resolved, the author traces the effect of a refracting surface on a wave-front diverging from a point, considering in turn the image formed by a spherical refracted wave-front corresponding to paraxial conditions, and the distortion of this wave-front due to aberrations. A fair knowledge of co-ordinate geometry is here assumed; but the mathematical treatment is clear and straightforward. Next, the terms in the expression for the distorted wave-front corresponding to the second-order Seidel aberrations are identified, and their effects on the image and their correction are explained. The last chapter deals with correction for colour, high-order aberrations, and the balancing procedure of the lens designer in achieving some cancellation of one aberration by a higher-order aberration of the same kind.

The book ends with a selection of problems, some simple exercises on the book-work and some particularly searching ones. None, says Mr. Selwyn, can be solved merely by substituting numerical values in a correctly remembered formula—a comment which the late Prof. John Perry might have expanded into many vehement paragraphs, and which conveys all too delicately a warning against the student's greatest temptation. But the reader who has followed Mr. Selwyn's treatment will naturally be thinking in terms of physics rather than of formulæ, so that perhaps even so gentle a reminder may prove superfluous. G. R. NOAKES

Higher Transcendental Functions

Vol. 3. Based, in part, on notes left by the late Prof. Harry Bateman, and compiled by the Staff of the Bateman Manuscript Project. Edited by A. Erdélyi. (Sponsored by the California Institute of Technology.) Pp. xvii+292. (London: McGraw-Hill Publishing Company, Ltd., 1955.) 49*s*.

THE third and final volume of this work, consisting of Chapters 14–19, deals mainly with problems much less tractable than those discussed in the previous volumes. Chapter 14 contains an interesting account of automorphic functions, a subject more akin to algebra than to analysis. It includes a summary of the theory, with references to text-books and research papers for those desiring to pursue the subject.

Chapters 15 and 16, on Lamé and Mathieu functions respectively, are concerned with differential equations the solutions of which are not expressible in hypergeometric form. As there is no general agreement about standard types of solutions, and as the formulæ are long and complicated, the editors have been forced to make a selection. In the case of the Lamé functions they have, wisely I think, employed the Jacobian elliptic functions; while in the chapter on the Mathieu functions they have followed McLachlan's well-known text-book. Abelian functions and multiply-periodic functions, for the discussion of which at one time large tomes were required, are only briefly referred to. Does a like fate await the Lamé and Mathieu functions? In addition to the Mathieu functions, Chapter 16 has sections devoted to spheroidal wave-functions and ellipsoidal wave-functions.

Chapter 17 contains an account of the functions of number theory. It is scarcely full enough for beginners in the subject, but may be useful to them as a guide; to the research worker the references will, of course, be useful. There follows a chapter on miscellaneous functions, such as Mittag-Leffler's and Wright's generalizations of the exponential and Bessel functions. In the final chapter is to be found a simple and interesting account of generating functions. The editors are to be congratulated on the completion of a most helpful aid to research in this field of mathematics. T. M. MacRobert

Progress in Cosmic Ray Physics

Edited by Dr. J. G. Wilson. Vol. 2. Pp. xi+322. (Amsterdam: North-Holland Publishing Company; New York: Interscience Publishers, Inc., 1954.) 45 florins.

THIS book continues worthily the work of the previous volume in presenting reviews of interesting topics in cosmic-ray research, primarily for the benefit of specialists in this subject and those closely adjacent. Many such people will already have used the book. Since this book was mainly written in 1952, and since this review appears late, it is necessary to indicate which portions have been seriously outdated. Unfortunately, Dr. J. G. Wilson's discussion of the unstable particles was written before the 1953 Bagnères conference at which the position about these particles was notably cleared. This conference now forms the best starting-point for the study of these particles. For the future, data from high-energy accelerating machines will probably lead to a rapid increase in the amount of information.

Prof. R. D. Sard's article on the nuclear interactions of μ-mesons at rest remains topical, but might need to be more closely tied to the investigation of mesonic atoms. Prof. H. Messel's article on the development of a nucleon cascade is the most convenient presentation of his theoretical work on a subject which is under actual experimental investigation at a number of centres. The article by Dr. L. Voyvodic is a valuable introduction to the technique of interpreting particle tracks in nuclear emulsion.

An Introduction to Deductive Logic

By Prof. Hughes Leblanc. Pp. xii+424. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1955.) 38*s*. net.

THE study of logic in its various forms is making rapid progress; and in some American universities it is accepted as an undergraduate course. This much is clear from the number of college texts which appear regularly, many of them valuable in particular fields. This one is distinguished for the delicate balance it maintains between philosophy and mathematics. In this way it provides—given the requisite degree of direction from a competent teacher—a very good guide to deductive logic.

In Great Britain, where the emphasis between theory and practice is a little different, a course of this kind might well help forward the training of physicists (including theoretical physicists), who might later become theoretical biologists, capable of coping with the structure of systems of immense complexity. The future, both national and academic, seems to need able thinkers orientated towards deductive logic. Training in some parts of the subject might also be expected to help in communication theory.

This book by Prof. H. Leblanc contains a couple of chapters devoted to two-valued and many-valued logics (including modal logic), coupled with 'classical' and intuitionist quantifiers. Then he discusses, among other topics, identity, classes and relations. Finally, comes a study of syntax. While there is nothing strikingly new in all this, the author has contributed something of value to the education of non-specialists which should assuredly yield worthwhile results. F. I. G. Rawlins

Science News, No. 37

Edited by A. W. Haslett. Pp. 128+16 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1955.) 2*s*. 6*d*.

WITH 'automation' the catchword of the moment in industry and elsewhere, it is not surprising that the enterprising editors of "Science News" have included an article on the automatic factory in their latest issue (37). This has been written by Dr. H. D. Turner, and in it he reviews the development of automatic machines, the growth of the automatic factory, and the need for functional thinking about technology to ensure that the second industrial revolution may avoid some of the harmful effects on society which accompanied the first. Another interesting article is one by J. B. Collins, who describes the inadequacies of existing artificial illumination and gives some pointers for research. The revolution in physics and philosophy brought about since Einstein published his first work on relativity fifty years ago are discussed by W. B. Bonnor. Other articles are by Prof. Kathleen Lonsdale, who writes about neutrons and atom patterns in crystals, and by Prof. J. B. Cragg, who examines the ecologist's role in Nature conservation. The general editor, A. W. Haslett, contributes his usual research report on a wide range of topics.

THE CHROMOSOME AS A PHYSICO-CHEMICAL ENTITY*

By Prof. C. D. DARLINGTON, F.R.S.
Botany Department, University of Oxford

1. Deoxyribonucleic Acid and Protein

SOON after the description of mitosis in 1878 its uniform mechanical character led German biologists to point out that uniform physiological properties were to be inferred in the chromosomes taking part. From this beginning the way has led inevitably to the recognition that chromosome behaviour had two aspects, physical and biological, that the second was the expression of the first and that, ultimately, the two must be seen together as a whole. Twenty years ago it was possible, following this view, to set out certain principles of chromosome mechanics and take note of a family of problems arising from them[1]; possible, that is, by the severe neglect of secondary details. Since that time, advances in the physics and chemistry of the chromosomes have brought the two sides within speaking distance.

These advances include two revolutions in our knowledge. The first depended on Caspersson's discovery that the chromosomes consisted characteristically of a combination of protein and deoxyribonucleic acid (DNA), which are jointly concerned in their reproduction and in their other activities[2]. Reproduction is, of course, a property equally of DNA-protein in the chromosomes and ribonucleic acid (RNA)-protein in viruses and other particles of the cytoplasm. Equally for both, Astbury showed that the peptide and nucleotide chains fit one another so that a template principle might apply[3]. This suggestion still seems fundamental, although the mode of fitting is debatable. On Caspersson's view, however, the DNA was accessory to the protein chain; their attachment was reversible in the nuclear cycle and discontinuous along the length of the chromosome, being interrupted in the stretched fibres between the staining units.

The second revolution disturbs this part of the account. The content of DNA does not, it seems, fall in the resting nucleus but remains constant until it increases in the course of reproduction. Thus DNA may well be at least as constant and continuous a structural component of the chromosome as any protein that it may contain.

Several kinds of evidence contribute to this view and carry it even further. Isolated sperm heads[4] and isolated chromosomes[5] have been shown to consist of DNA and protein and a small and variable quantity of RNA. Now the protein varies in character. It is supposed to be largely histone in body-cell nuclei of animals. But, in fish sperm (which carry, in a sense, an India paper edition of the nucleus) it is largely protamine, a smaller molecule than histone, with a different amino-acid content[6]. Other 'residual proteins' in nuclei, moreover, vary in quantity[5].

For the DNA, on the other hand, several kinds of evidence have been obtained in favour of constancy. In regard to quantity, Boivin[8] and Mirsky[9] and their collaborators have shown that a nucleus with a standard chromosome complement (and I shall return later to define what this means) contains a constant amount of DNA. In regard to quality, Chargaff[10] and others have shown that DNA (unlike RNA, which varies from tissue to tissue) has nucleotide proportions in terms of purine and pyrimidine bases, characteristic of the chromosome complement, or the sum of the genes, or the genotype. The analogy here is with the letters in a book the proportions of which differ in different works but are constant in one work or at least one edition. The infinite diversity of words, or of genes, is not, of course, revealed by quantitative analysis of whole books or whole nuclei in terms of these smaller units.

A second property of DNA revealed by these determinations has been the equality in number of the large purine and the small pyrimidine bases. This, together with the crystallographic picture and the template principle, has suggested a new model of DNA[11]. According to Watson and Crick, the DNA normally exists in the chromosome as a double and coiled nucleotide column, each side of which, if separated from its partner, can act as a template for the assembling of the other. On this basis DNA would appear as a self-sufficient genetic structure with the protein at least mechanically subordinate. But, of course, we do not need to take such an extreme view: equality and reciprocity are also conceivable.

This new knowledge leaves some uncertainties and a few apparent contradictions. But it allows us to reconsider the rules governing a part of chromosome behaviour, those concerned with changes of shape within the nucleus, which I have called the internal mechanics of chromosomes. It allows us to find out how far the micron point of view agrees with the angstrom point of view.

2. Spiralization

The reproductive or mitotic cycle of the nucleus depends on the alternation of two states, the nucleus and the chromosomes, each of which is stable in its internal mechanics. In the metaphase or most contracted state of the chromosomes the gene-strings are packed for transit in a small, if not the smallest, bulk; and the genes themselves are inactive. In the resting nucleus the chromosomes have absorbed water and have swollen to tens or hundreds of times their metaphase bulk. The genes are, or at least may be, engaged in reproducing themselves and in producing also RNA (ribonucleic acid) and proteins. Both these, partly by way of a special globular structure, the nucleolus[12], are believed to pass into the cytoplasm; but their relative importance is debatable, like that of the DNA and protein in the reproduction of the chromosome.

The physiological activity of the chromosomes is shown very easily. Nuclei which differ in content of

* Substance of a paper to Section B (Chemistry) of the British Association meeting at Bristol read on September 1.

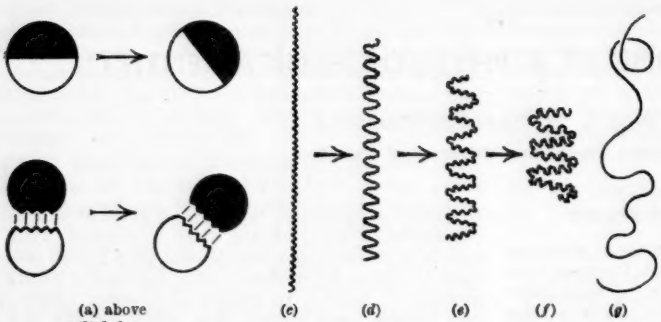

Fig. 1. The three levels of spiral formation. (*a*) twisting, an internal-molecular change; (*b*) rolling, a relational change demonstrating the pairing face; (*c, d, e, f*) coiling stages in the successive development of major, minor and perhaps third-order coils during prophase; (*g*) relic coiling formed by relaxation in the resting nucleus

genes are regularly produced in the spores which arise at meiosis in most plants: and when they differ the spores diverge in the rate of their growth, a divergence which is the basis of fertility and sterility in plants. The reproductive activity of the chromosomes, on the other hand, shows itself in their double structure: when they appear at the beginning of the next mitosis they have divided into pairs of chromatids. This change is reflected in the doubled DNA content of the nucleus[13].

Side by side with the physiological cycle of mitosis there is also a mechanical cycle which has been called a spiralization cycle. In the first stage or prophase of mitosis each chromosome consists of paired chromatids arising from reproduction. These separately assume a helical or coiled structure which reduces their length to about one-tenth at the metaphase stage[14]. When the chromatids reconstitute daughter nuclei at the end of mitosis by absorbing water, they stretch these coils; but movement is limited by space and the coils fail to straighten. By a kind of hysteresis they are retained right through to the next mitosis, where they reappear as relic coils. The minute incipient internal coils[1] arise quite independently of the large decaying relic coils (Fig. 1).

Three questions now arise. (1) How is the coiling set up? (2) What determines its direction, whether left- or right-handed? (3) Is the visible coiling sufficient to account for all changes in length?

(1) The coiling might be set up by rotation of the ends, just as we coil a piece of wire; if, that is, any outside force were conceivable that could twist ends of fibres in a cell against the resistance of the fibres themselves. This idea, however, is quite excluded by the fact that chromosomes, which have no ends at all, can take a spiral form. In various plants where ring chromosomes have been produced experimentally, they meet with frequent accidents. But they can take a spiral form and they can reproduce. Moreover, in *Drosophila* they propagate themselves well enough to keep the fly alive and, what is more remarkable, allow it to pass them on to its progeny after a due amount of crossing-over[15].

Scarcely less decisive is the evidence of complexes in which all rotation has been stopped by an experimental breakage and reunion of chromatids, which can unite in one body the whole chromosome complement[22]. On such grounds the force setting up coiling must be supposed to be internal. There must be a molecular twist which determines and at the same time compensates for the internal coiling (Fig. 1). Now the daughter rings which a ring chromosome produces fall apart, usually without interlocking: this molecular twist must therefore at the same time govern the direction of reproduction of a ring chromosome. In other words, each chromosome must be supposed to have a reproductive or splitting or cleavage face which is continuous throughout its length and continuous also throughout the mitotic cycle.

(2) The direction of coiling of chromosomes is another matter. Left and right systems are found together in the same nucleus and, in diploid nuclei, in the same pair of chromosomes. The direction is, however, probably constant for each arm of a chromosome at each mitosis. Now, if the direction of twisting as well as the capacity for twisting were inherent in each piece of chromosome, the exchange of pieces which is continually going on in the course of evolution would have led to utter disorder long ago. The direction, therefore, must be under unitary control. Probably the agent is the centromere, the non-spiralizing group of genes which, in each chromosome, influences or directs all movements, including chemical movements, in which the chromosome has to behave as a unit (Figs. 2, 3 and 4).

(3) The answer to the third question is given by certain resting nuclei of glandular cells in flies. In the salivary glands, for example, the chromosomes are visible in the resting nuclei and are probably stretched to as much as three hundred times their

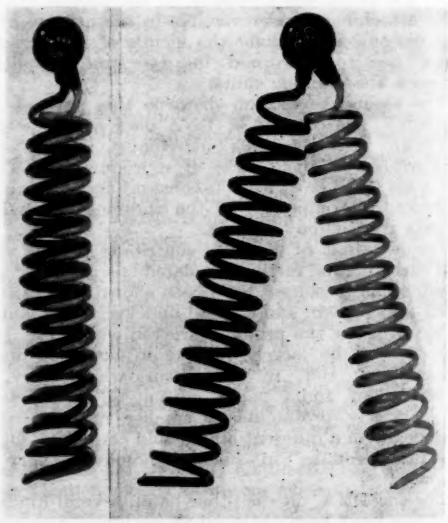

Fig. 2. Coiling of two sister chromatids (or nucleotide columns) in which free separation is possible because the cleavage coiling compensates for the individual coiling

minimum length[14]. Clearly, the single visible coil of mitosis is not enough to account for this degree of change. Part of the explanation is revealed at meiosis.

Meiosis is a distinct type of mitosis in which corresponding chromosomes pair, a process I shall return to later. So far as coiling is concerned, however, the metaphase chromosomes at meiosis show two special features. The first is that the paired chromatids may coil, not separately to form two rods as at mitosis, but jointly to form a single rod. When they do so, however, they are still capable of falling apart instantaneously when the chromosomes move to opposite poles (Fig. 2). In other words, we again have a strictly compensating coil and a strict cleavage face as in ring chromosomes.

The second feature of meiotic coiling is that a minor spiral (first described by Fujii in 1926) can be seen beneath or within the major spiral (Fig. 3). This two-order system of coiling goes with a greater shortening of the chromosomes. But since all degrees of shortening occur, we may suppose that there are two orders of coiling equally at mitosis and meiosis. Indeed, in view of the stretching of salivary-gland chromosomes, we may expect yet a third and lowest order of coiling or folding beyond the resolution of visible light.

How do these systems of coiling develop? All visible coiling gets larger in amplitude as its develops, a principle which even extends to the last stage of relic coiling. Might there not be, therefore, an indefinite succession of coilings following one another? The answer to these questions depends on another unknown which we may now consider.

3. Polynemy

The characteristic structure of a polypeptide chain or a nucleic acid or a chromosome depends on the lengthwise repetition or polymerization of a unit to give a fibre. The reproduction of a chromosome depends on a cross-wise repetition, a lateral polymerization, of the fibre. But is the chromosome itself a single ultimate unit? Until recently, this was assumed. But the double nucleotide column at once doubles the minimum element. The biological evidence goes further than this.

Natural protein fibres are usually in bundles. Under certain special treatment, genes and chromosomes can behave as though they were composed of such bundles the constituents of which are capable of mutating or breaking independently[16]. The appearance or emergence of a mutation is then delayed several cell generations[17]: in *Amoeba* five generations suggest thirty-two fibres[18]. The effect of a break followed by reunion is to cause the appearance in the cell of exchanges looking like chiasmata. But they are exchanges between fractions of chromatids.

What does this mean? An analogy is helpful. The chromosome in genetics has a validity like that of the atom in chemistry, unconditional for ordinary purposes but conditional for extraordinary purposes. Under ordinary conditions, in normal mitosis and normal reproduction, the chromosome acts as a unit. But under extraordinary treatments the unit is decomposed and forces us to admit that it is, after all, a bundle of fibres.

How many fibres? We can make only comparative estimates. Closely related plants and animals with similar numbers and shapes of chromosomes often

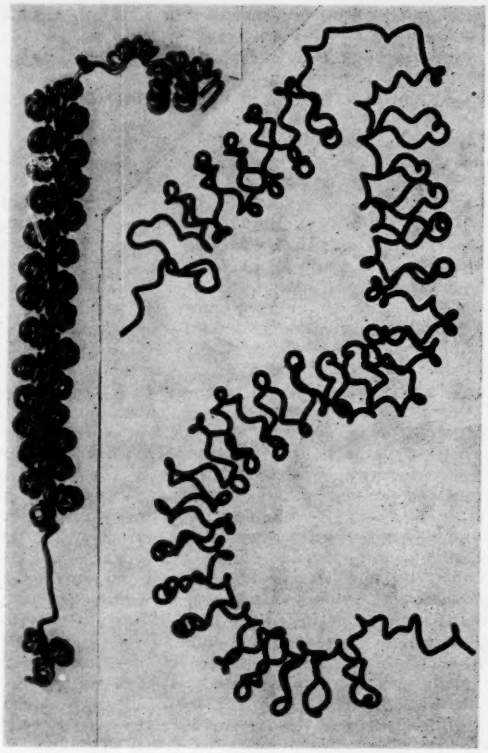

Fig. 3. Double system of coiling in a chromatid as seen at first anaphase of meiosis, and relaxed as relic coils in the ensuing resting nucleus

show wide differences in size. A range of the order of 128 : 1 seems indisputable, and it may be much higher[19]. Within the same organism a reduction of size to one-eighth has been found[20]. This happens only in blind-alley tissues of plants. In animals, however, of many groups, repeated chromosome halving is characteristic of the cleavage divisions of the egg[21,22]. In DNA economy, for which cleavage is a crisis, this seems to be the counterpart of 'diminution' in *Ascaris*. But it is a reversible diminution, for in the germ line the size must later be restored completely. In the body cells, on the other hand, we do not know that restoration is always complete: chromosome size, like chromosome number, may sometimes vary from tissue to tissue. Again, following X-raying of roots, chromosomes have been found to come into mitosis at about half their standard size[23]. Conversely, in haploid newts, the chromosomes are said to keep double their normal size, compensating, as it were, for the deficiency in numbers[21].

Can different degrees of multiplication, of polynemy as we may call it, occur in the same nucleus or the same chromosome? Only once, as a result of hybridization, can this be supposed to have been seen. Species within many genera of plants and animals often have corresponding chromosome complements differing in size. These sometimes retain their differences in first crosses. Wanner and Bruhin[24] have succeeded by heat treatment of a species cross in breaking and recombining segments of the thick and thin chromo-

somes and so producing mosaic chromosomes. Such mosaics have never been found in Nature. It may be that the same general control which keeps all the chromosomes in step in a uniform nucleus can also usually put them right when they have fallen out of step.

Now if we consider the whole range of animals[9] and plants[25] known for their chromosome sizes and their DNA values, we notice that both vary over a range of 1,000 : 1. Where both are known, they vary in proportion : newts and lilies are large, mammals are medium, and fungi small. Again, we have evidence of a uniform nucleo-protein structure in the chromosomes. As a corollary, where we find related species the chromosomes of which are of similar shape but differ in size, we must assume that a difference in cross-wise multiplication, in polynemy, is responsible ; and the more so where the chromosomes vary in size within an individual.

Only the species test has so far been made. Hughes-Schrader has compared the DNA values of two species of the mantid *Liturgousa* which differ in size of chromosomes. One with smaller chromosomes has twice the number of its relative. It is apparently a tetraploid, one of the half-dozen cases known in animal species with sex chromosomes. But the DNA nuclear contents of the two species are the same[26]. Thus the chromosome, by lowering its polynemy, has compensated for raising its polyploidy ; the opposite to the haploid newt. In many plant genera these size and number relations hold[19]. In such genera DNA value may be expected to change with chromosome size.

In this argument, it will be seen, we are inverting the Boivin–Mirsky rule and using it to correct itself. We are using the quantity of DNA to define the complement of chromosomes and hence to reveal where the character of the complement has broken down or may be expected to break down.

A question of analytical practice is also worth noting here. Hitherto it has been convenient to take genotypic, structural and numerical change as the three dimensions of all variation in chromosome behaviour. Here, however, they cease to be sufficient. Polynemy falls in a class by itself, and is best considered as a fourth dimension of variation.

4. Reproduction

With the assumption of polynemy there are two levels at which the processes of gene and chromosome reproduction have to be considered : the ultimate unit of nucleo-protein fibre and the whole chromosome bundle, whether of thirty-two units, as has been assumed in *Amoeba*, or 128, as I would suppose in the large-chromosome lilies and amphibians. The unit fibre of the Watson–Crick model requires the separation of the paired and rolled or coiled columns of nucleotides so that each may act as the template in the building up of a new double column. Further, the mutual template relation of nucleotide columns still leaves us in need of a nucleotide template for protein manufacture. This has its ordinary stereochemical problem with the far-reaching implications discussed by Dounce and others[27] ; and it shares the common uncoiling problem of the nucleotides.

A separation, such as would be required for reproduction of the nucleotide and protein columns, would be possible if their coiling itself represented the molecular spiral the existence of which we have long predicted from the evidence of microscopy. Can it be taken by its amplitude to represent the molecular spiral ? The answer depends on two conditions that are still uncertain : the degree of polynemy that can be assumed in chromosomes of particular sizes ; and the position that is to be assigned to the protein components, the histones and residual proteins of Mirsky and his collaborators[7].

The reproduction of individual fibres will be the necessary antecedent of the splitting of the whole bundle, unless the chromosome is to step down to half its former size. The evidence of X-ray breakage indicates that this event coincides with the beginning of mitosis at the moment when the chromosomes begin to become spiral and cease to be breakable[28]. We may suppose that bundles beyond a certain size are unstable, the limit being characteristic of particular types of cell. A shift in stability will give a change in chromosome size up or down. If the shift is in the germ track, the result may even have the character of an evolutionary change and it has been described as a 'mutation'[19].

5. Meiosis

When the splitting of the chromosomes does not coincide with the beginning of mitosis but, on the contrary, follows it and consequently takes place visibly and publicly, we have the other type of nuclear division : we have meiosis. We then discover several crucial tests of the mode of chromosome reproduction.

At meiosis the chromosomes become visible or 'enter prophase' when still single ; that is, before they have reproduced and also before they have completely untwisted. In this state chromosomes of a kind pair, piece by piece, zipwise. There are two probably universal mechanical properties of this pairing. First, the association or attraction is limited at any one point to twos, even when, as in polyploids, there are three or more of a kind. Secondly, the chromosomes complete their untwisting and in so doing they set up a fourth kind of spiral system, that of relational coiling. For once they rotate their ends. If the pairing and coiling get out of step (as they do in hybrids) the chromosomes snarl like string under torsion and this upsets their later development. Whether the chromosomes roll right or wrong, they must roll around one another until their relational torsion reaches equilibrium with their internal torsion, the common textile-spinning equilibrium. They do not slip. Evidently the chromosome has a pairing face just as it has a cleavage face (Fig. 1,*b*).

Now, it is difficult to see how columns of nucleotides could have such a pairing face when they are already paired : they are saturated. But columns separated and prepared to attract the components of daughter columns could have a pairing face and might well be limited to attracting one partner. The face of the pairing chromosome appears to do just what the face of the reproducing chromosome does : it attracts to itself similar particles in similar positions and in equal quantities. But the result is only momentarily the same. Equilibrium is not reached ; or if it is reached, it is soon disturbed again. The preparations for reproduction are continued or resumed. This happens in the following way. Successive units of activity along the chromosome thread, the chromomeres (Fig. 4), are continuing to produce the proteins which, according to Caspersson, are pushing them

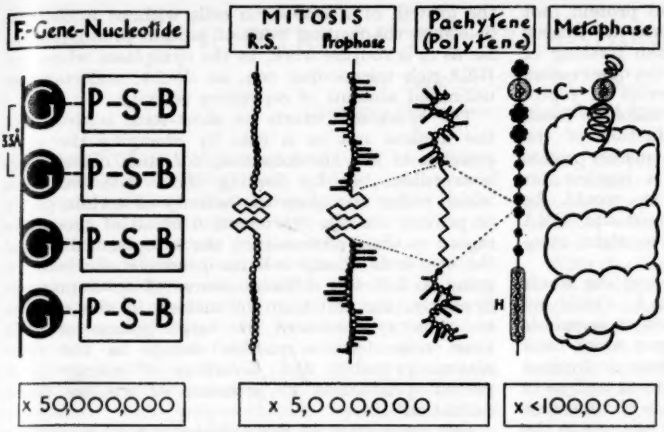

Fig. 4. The chromosome considered on the earlier assumption of a single protein thread with a single spiral detachable DNA column and represented at three magnifications
F, protein fibre; *R.S.*, resting stage; *C*, centromere; *H*, heterochromatin (reduced from Darlington and Mather, ref. 30)

apart and making them visible. The protein and DNA content of the nucleus rises, and when it is doubled[29] the chromosomes split and at the same moment they fall apart.

Thus, although pairing is a substitute for reproduction and may well delay reproduction, it does not prevent it. Why? The rolling or relational coiling of the partners is a sign that the partners are not themselves completely uncoiled at the molecular level and are not therefore attached along one continuous face: the pairing face and the splitting face do not agree. This disagreement may be the reason why pairing is not a substitute for reproduction. The torsion which underlies it is certainly the reason why reproduction is usually followed by a sequence of mechanical changes. For the torsion is released when the chromosomes split into weaker half-threads, the chromatids. It is released by the breakage at corresponding points of pairs of chromatids, their unrolling and reunion in new combinations; all of which together the breeder calls crossing over and the cytologist calls the formation of a chiasma. Both these vary in frequency, as does the torsion which precedes and apparently determines them.

Two points now concern us about these processes. First, the universality and potential uniformity in their time, place and action demonstrate the uniformity in molecular structure of all chromosomes and of their properties of pairing and cleavage. The great range of size and, as we suppose, of polynemy, does not upset the system.

Secondly, a conditionally particulate structure of the chromosome is suggested by chromomeres which can sometimes be seen, and by genes which can correspondingly be inferred. Such a structure, in turn, suggests that only in the intervals between the particles will crossing over usually occur. The chromomeres are condensed regions of coiling or folding joined by stretched fibres which must be weaker. The fewer the number of weak points at which breakage of the two chromatids can occur, the more exactly opposite will the breakage be. It also seems likely that the clustering and folding within chromomeres are related to the physiological integration of the parts of genes (Fig. 4). For both vary in different parts of the same chromosome[30] and the same part varies in different tissues of the same organism[31]. These variations must have a molecular basis and that is a problem we have to keep in mind.

6. Free Deoxyribonucleic Acid

It is important to see how far we can go with the assumption that DNA is the structural basis of the gene and the chromosome. But we know that DNA can exist in a free state. The occurrence of bacterial transformation shows how important this free state can be. In animal eggs and in the pollen mother cells and pollen grains of plants, reserves of DNA in excess of the nuclear constant have been determined[32], and in the cytoplasm granules containing DNA have been identified[33]. Moreover, there have been found in the Feulgen-staining of chromosomes variations which are related to the capacity for spindle production in the cell at mitosis. This is particularly striking in the differentiation of the mammalian bone marrow, where the red and white blood corpuscle precursors, as described by La Cour, are respectively glutted and starved of DNA; the starved chromosomes are thinner and also longer than the glutted ones[34].

These general variations are to be contrasted with a second type of variations which are cyclical and localized. In many plants and animals there are particular segments of particular chromosomes which seem to accumulate DNA in an unpolymerized or fluid state during the resting stage of the nucleus. These segments are probably groups of smaller and less specific genes[30]. They are known as heterochromatin. Quantitative observations on the cyclical behaviour of heterochromatin are much needed. For the time being we can only say that it appears to differ from the rest of the chromosomes in the rate at which it undergoes mitotic changes, and the difference can be exaggerated at low temperatures. At metaphase, the heterochromatic segments may then appear to be deficient in DNA; they show nucleic acid starvation. They differ from the rest of the chromosomes somewhat as the chromosomes in the white cells differ from those in the red; they are thinner and more weakly staining than the unstarved parts. They remain, however, the same length as when unstarved[35].

In extreme circumstances where there is little heterochromatin in the nucleus, its starvation can also, it seems, be extreme. In certain polyploid plants and in the *X*-chromosome of the hamster[36] and other mammals[37], formation of spirals fails with extreme starvation. This was the first indication we had that DNA was an essential agent in spiral formation, the nucleotides being supposed to be arranged like the steps in a spiral staircase (Fig. 4).

The recent experiments of Mirsky and Ris[7] on isolated chromosomes have carried us a great deal further. They have shown that it is the combination

of the polymerized DNA and residual protein (not histone or protamine) which maintains the fibrous structure and thus must determine the forming of spirals of the chromosome. Similarly, the observation that DNA-starved segments show errors of reproduction, sticking of chromatids, was taken to mean that DNA was essential for reproduction of the protein thread. But, of course, we merely notice the DNA because we use it as a marker for staining in routine observation. It would be better, therefore, to say that the protein and DNA are necessary to one another in the right combination.

Are we justified, then, in reconsidering the whole assumption of nucleic acid starvation? Could we suppose that the starved chromosomes or segments in all these cases are indeed chromosomes which have divided without reproduction of their individual fibres—chromosomes reduced in protein as well as in DNA to half-strength? On this view, a chromosome with a thin starved segment would be like one in the *Crepis* hybrid between two species with two levels of polynemy.

A number of properties of starvation put this view out of court. First, with local starvation, minute segments of ordinary chromosome can be intercalated in a length of heterochromatin. They are then visible as minute darkly staining points in the starved segment[38]. Secondly, with general starvation and, conversely, with general plethora, there is always a correlation with spindle development and probably general protein production in the cell[39]. Such differences have no parallel in the group of cases where chromosome size is spontaneously or experimentally stepped down.

The two bodies of evidence of DNA as a solely genetic structure on one hand, and as a partly physiological fluid on the other hand, are now in plain contradiction. Before we can resolve this contradiction, however, we shall need to solve problems in the wider field of cell-nucleus relations.

7. Cell and Nucleus

The nucleus is the most highly organized part of the cell, and it has hitherto been accessible to more varied modes of experiment and analysis than the cytoplasm around it. It was necessary to establish the nuclear framework of heredity before we filled in the cytoplasmic details. We had to understand nuclear genes before we could invent plasmagenes[40]. So it must be, to some extent, with the chemistry underlying heredity. But we must all the time use the relations of the two, and the relations of chemistry and genetics to keep our bearings.

The predominance of the cytoplasm for the short-term effects which we call physiological and the predominance of the nucleus for the long-term effects which we call genetic, has led to a continual conflict of opinion. On a basis of chemistry and also of microbiology the conflict is being resolved. Nucleus and cytoplasm propagate their enzymatically significant proteins by means of genetic particles, which depend, one on DNA, the other on RNA. The nucleus exerts its long-term control over the cytoplasm by permanently changing its composition; by passing out into it RNA, perhaps also protein, and exceptionally, also DNA. But, like a good administrator, it delegates as much of its work as possible to the cytoplasm. It delegates the business of respiration to the mitochondria, and as Brachet showed, from the growth of *Acetabularia* cells without nuclei[41], it delegates the routine work of protein production, so far as it is routine work, to the cytoplasm where the RNA-rich microsomes can, no doubt, undertake an unlimited amount of repetitive activity.

The cytoplasm exerts its short-term control over the nucleus not as a rule by changing the composition of the chromosomes, for such changes are irreversible, but by feeding them with materials which either stimulate the activity of certain genes, or provide for the reproduction of all of them. In regard to these alternatives, the cytoplasm differs at the two ends of any cell the products of which are going to follow a different course of development[30]. Similarly, the initiation of meiosis in the nucleus, so often synchronized for large groups of cells, must arise from a sudden change in the cytoplasm, probably the diversion of energy from protein production to processes of nuclear transformation[42].

Our knowledge of the chromosome as a physico-chemical entity will continue to be gained in part from these physiological reactions which we can so readily control in our experiments. We have to continue trying, as in the present discussion, to combine ideas expressed in the three languages of the angstrom, the micron, and the naked eye. We may fumble in our efforts to translate; but in the end we shall learn the same language.

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CHEMISTRY OF THE GRAM-STAINING PROCESS*

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RIBONUCLEIC ACID (RNA) and deoxyribonucleic acid (DNA) form a high proportion of the organic matter of all bacteria and other micro-organisms. In some yeasts the nucleic acid components may amount to 20 per cent of the dry weight of the cells. While it is quite evident that deoxyribonucleic acid plays a vital part in cell division, constituting, with combined protein, the major part of cell genes and chromosomes, it is by no means clear what are the major functions of ribonucleic acid. Evidence is growing that it plays an important part in protein synthesis, and it also seems to be closely associated with polysaccharide synthesis. Ribonucleic acid forms a high proportion of plant viruses, while deoxyribonucleic acid is present in animal viruses and bacteriophages.

We have tried to discover the significance of both types of nucleic acid on or near the surface of some bacteria, and what connexion they have with the complex surface polysaccharides or 'capsular' components of the bacterial cell.

It is well to remember that there are enormous differences between individual bacteria, and each eventually will have to be treated from the chemical point of view as an individual. Our bacteriological colleagues have built up a vast store of knowledge regarding the activities of all these individuals. By microscopic, staining, fermentation and immunological techniques, it is possible to identify them all rapidly and with great precision. The chemical reasons for the characteristics of morphology and of staining reactions are but little understood. One in particular is the Gram stain, the most commonly used of all bacteriological staining techniques. It consists, as discovered by Christian Gram, a Dane, in 1883, in staining fixed smears with an aqueous solution of a dye of the *p*-rosaniline series and mordanting with aqueous iodine. Subsequent washing with alcohol or acetone removes the dye from so-called 'Gram-negatives' and leaves the 'Gram-positives' stained deeply blue-black. Animal and vegetable cells are not affected by the Gram stain. There are many important microbiological differences between Gram-positives and Gram-negatives. Thus Gram-positives such as the pneumococci usually can be knocked out by chemotherapeutics and antibiotics but give, on injection or after infection, a poor immunity. Gram-negatives, such as the dysentery bacillus, are much less susceptible to chemotherapeutic agents and antibiotics but can give rise to a high degree of immunity.

It seemed apparent that there must be considerable differences between the surface components of Gram-negatives and Gram-positives. Many theories had been put forward in the past to explain the Gram reaction, and most of the early ones were based on studies of the diffusion of the dye through the cell membrane and its subsequent failure to pass out again. Many organisms can readily lose their Gram-positive character under a variety of conditions such as 'old age', treatment with alkalis and acids, and during the process known as autolysis. The resultant Gram-negative cells usually appear smaller and shrunken, and there is an apparent loss of surface material which gives in some cases a reaction for nucleic acids.

With the late Dr. H. Henry we showed that suitable Gram-positive bacteria could be 'stripped' of an essential component of their Gram-positive material by extraction with 2 per cent sodium cholate at 60° C. and thereby rendered Gram-negative. A fraction obtained from material in the extract, itself Gram-negative, could be 'replated' on to the Gram-negative 'cytoskeletons' under reducing conditions to restore in a large measure the Gram-positive characteristics.

This essential part of the extract was identified as the magnesium salt of ribonucleic acid, and we expressed the view that the dye-retaining material, that is, the 'Gram complex', was a magnesium ribonucleoprotein. This was eventually isolated from a number of Gram-positives by a short autolytic procedure and dissociated into Gram-negative magnesium ribonucleic acid and a Gram-negative basic protein which, if the —S—S— groups in the latter were kept intact, would re-combine to give a Gram-positive mass.

Further support came from various workers who showed that ribonucleases would destroy the Gram complex. Striking effects on Gram-positive cells can be obtained with reagents which have a strong affinity for ribonucleic acid. Lithium salts, for example, will cause the nucleic acids to aggregate into masses at the sides and ends of rod-shaped bacteria. Surface-active agents also cause the ribonucleic acid to clump initially and then to disappear. The significance of both magnesium and ribonucleic acid can be demonstrated with one organism, *Clostridium sporogenes*, a Gram-positive, which will grow in Gram-negative form under adverse cultural conditions such as magnesium starvation. Addition of magnesium salts will slowly restore the Gram-positive state, while addition of magnesium–ribonucleic acid will rapidly restore both living and dead organisms to the Gram-positive state.

In removing the surface layers of Gram-positives, many other macromolecules are removed, for example, polysaccharides, fats, phosphatides, etc.; but only ribonucleic acid will 'replate' in any measure. The replating can be seen in a striking manner by photographs in the ultra-violet, where the nucleic acids absorb. Dr. P. Mitchell, of Cambridge, has claimed that the essential part of the Gram complex is a '*P*' factor which is a phosphatide. In our hands, however, extraction, for example, of *Cl. welchii* cells, with boiling methanol and ether for several hours which would remove all Mitchell's factor, leaves 80 per cent of the cells Gram-positive. Phosphatides may help to absorb more of the dyestuff in the intact cell.

In true Gram-negatives, which have a significant ribonucleic acid content, and in Gram-negative cytoskeletons, the magnesium is all in ionic form; whereas in Gram-positives the major proportion of it is in co-ordinated form.

* Abridged from a paper entitled "Taking the Nucleic Acid Jackets off Bacteria" to Section B (Chemistry) of the British Association meeting at Bristol read on September 1.

Magnesium plays an important part in bacterial cell division and is an essential element for most Gram-positives, which require a higher proportion than do Gram-negatives. Since we have not been able to 'plate' magnesium ribonucleic acid on to true Gram-negatives, we consider that they possess proteins located near the surface which are in quite a different class from those in Gram-positives.

It has been possible, on the other hand, to use ribonucleic acid from Gram-negatives and from many other sources to 'replate' Gram-negative cytoskeletons, so that ribonucleic acid does not show any specificity in this type of interaction with protein. In no case could deoxyribonucleic acid be plated on to cytoskeletons. Recently we have made many efforts to obtain nucleic acids from yeast by means of mechanical disintegration of cells, and we have noted in such cases that the cytoskeletons cannot be restored to the Gram-positive state, neither can cytoskeletons be rendered Gram-negative by autolysis methods. The latter may be due to the very powerful and persistent action of ribonuclease, and only quite recently have we been able to isolate nucleoproteins from yeast free of this enzyme.

We have been able to discover that the useful antiseptic detergent, cetyltrimethyl ammonium bromide ('Cetavlon'), exerts its powerful action on micro-organisms by combining strongly with the surface ribonucleic acid. We have shown that there is a close association between the ribonucleic acid–protein surface components of the Gram complex and polysaccharide synthesis in some micro-organisms. This can be shown very well with those *Streptococci* which produce dextrans and lævans. It is possible that the ribonucleic acid of the Gram complex is part of the enzyme system, for while purifying dextrans and lævans and many other polysaccharides, ribonucleic acid can be shown invariably to be present as an impurity which is difficult to remove by fractionation methods.

The close association of nucleic acid with polysaccharide synthesis can be shown in a much more striking manner in the *Pneumococcus* group of bacteria, in which case deoxyribonucleic acid takes the vital role. Deoxyribonucleic acid 'jackets' in this group can be changed in a dramatic way, and when the jackets are changed we get a change of polysaccharide 'overcoat' also, for the deoxyribonucleic acid jackets and overcoats apparently have to match. The seventy types of pneumococci are detected by means of their serological reactions. Each type of *Pneumococcus* possesses a structurally different polysaccharide of high complexity, and running through the whole group is one common 'somatic' or group polysaccharide. Some of the structural differences between the specific polysaccharides are very profound, for example, as between types 1 and 3, while others have closely similar structures, for example, types 3 and 8.

In 1928 an Englishman, Griffiths, discovered the transformation of types whereby one type of *Pneumococcus* could be transformed into another thus :

Rough Type 1 live cells	+	Heat-killed encapsulated cells of smooth Type 2	→	Type 2 live cells
also				
Rough Type 2 live cells	+	Heat-killed smooth Type 1	→	Type 1 live cells
also				
Rough Type 2 live cells	+	Heat-killed smooth Type 3	→	Type 3 live cells

Dawson and colleagues in the United States later confirmed these discoveries, and showed that any type could be transformed through its unencapsulated live form ; while Alloway, also in the United States, dissolved the heat-killed cells in sodium cholate and showed that extracts would still achieve the transformation of types. Then came the dramatic work of Avery and his colleagues in the Rockefeller Institute, showing that the factor achieving the transformation was deoxyribonucleic acid—a kind of type-specific deoxyribonucleic acid in each case.

A number of types have now been transformed with the appropriate highly purified deoxyribonucleic acid. The transformed cell takes on all the properties of the new type, including the property to reproduce the transforming deoxyribonucleic acid. Other bacterial types have also been transformed, and, in addition, other properties such as drug resistance have been transferred.

If we consider the mechanism of the biosynthesis of polysaccharides, we know that three components are required, namely, enzyme, substrate (a specific glucoside) and a primer. The latter must possess appropriate receptor groups and must be of the same pattern as the polymer to be synthesized, and it must possess a minimum number of sugar units in its chain.

According to these requirements, then, the transforming deoxyribonucleic acid could possess, and carry with it, its polysaccharide primer. Possibly a simple mono-layer would be sufficient, and it need be no larger than an oligosaccharide. In my view, it would mean that the so-called 'memory' of the transforming deoxyribonucleic acid is not solely due to its own structure, but is due in part to the specific carbohydrate structure holding it rigidly in shape until it meets, in the Rough form of an unencapsulated *Pneumococcus* cell, a receptive protein with which it can combine to re-form the complete enzyme system for polysaccharide synthesis. It is of interest to note what remarkable differences there are between the chemical structures of the *Pneumococcus*-specific polysaccharides, which are probably built up as 'block polymers'.

One of the great fields of investigation awaiting the attention of chemists is that involving the isolation and the chemistry of nucleoproteins. Determination of the mode of linkage between these two groups of natural molecule and their isolation in a form whereby biological function is retained will help in solving problems connected with the chemistry of living matter—especially with chromosomes, enzymes and viruses.

Our work has shown that their dissociation and recombination to retain 'living' attributes may not be too difficult a problem.

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RADIATION DAMAGE TO METALS AND ASSOCIATED PROBLEMS

IN the course of the annual autumn meeting of the Institute of Metals, held this year in Buxton, a discussion was held on September 22 on the subject of "Radiation Damage in Metals". The Metal Physics Committee of the Institute had arranged this discussion under the chairmanship of Prof. R. W. K. Honeycombe, professor of physical metallurgy in the University of Sheffield, and speakers were drawn from the Metallurgy Division of the Atomic Energy Research Establishment.

Dr. M. J. Makin spoke about the effect of radiation on the mechanical properties of metals and the importance of knowledge of this phenomenon when undertaking the building of nuclear reactors, much of the structure of which is inevitably exposed to a heavy flux of neutrons. An experiment in which the mechanical properties of nickel were tested before and after irradiation showed, in respect of the irradiated sample, a considerable increase in yield stress, some reduction of ductility and a general lifting of the stress–strain curve. The rate of work-hardening was less in irradiated material than in the original. The mechanical properties of irradiated specimens recorded at different testing temperatures showed that the results obtained were very dependent upon temperature, while a further variation in these properties was related to the temperature at which the irradiation took place. Some of the irradiation effects can be annealed out. Experiments with copper show that 300–400° C. is a suitable range, corresponding to an activation energy of approximately 2 eV. With nickel, the range is 350–400° C., suggesting that the activation energy is about the same as that of self-diffusion. The temperature indicated for nickel is rather lower than that at which cold work anneals out and, further, the reduction of ductility by irradiation is much less than that brought about by cold work.

The effect produced by irradiation on mechanical properties appears to resemble more closely the change produced by the addition of an alloying element than, as had been suggested originally, that induced by cold work. Irradiation of material with a ductile-brittle transformation raised the transition temperature. Work on single crystals of ductile metals shows that the rate of increase of yield stress is not linear; the effect appears to be proportional to the $\frac{1}{2}$ power of the neutron dose, and there is no evidence of a saturation point. Efforts have been made to picture a mechanism involving the displacement of atoms by fast neutrons. Thus, Brinkman, discussing copper, has suggested that the knocked-on atom actually melts a very small region of the crystal and that solidification is so rapid that the atom will not return to its original position. Another suggestion is that the copper atoms knocked out of the lattice migrate in clusters, forming a pseudo-precipitate which is attached to dislocations.

Discussing techniques used in studying radiation damage, Mr. O. Plail said that the main divisions of this study—irradiation and subsequent examination—both call for special experimental techniques and scientific apparatus of novel types. It is necessary in the first place to avoid damage to the pile and, in the second, to carry out delicate tests by remote control on specimens which are strongly radioactive. Mr. Plail's contribution clearly demonstrated the demands now made on technicians and apparatus constructors and how well these demands have been met.

Dr. P. C. L. Pfeil dealt particularly with the preparation and microscopic examination of irradiated specimens. The microscope used is of the usual inverted type, but the optical system following the objective is replaced by a high-definition television camera. The camera is connected to a large monitor-tube mounted in a conventional cabinet, and the image of the specimen is displayed on this monitor. A very high standard of resolution has been attained, photographs of the screen image (magnification, × 1,000) being remarkably clear. Dr. Pfeil discussed the microstructures revealed by such examination and mentioned that a Russian delegate at the Geneva Conference reported that a sample of alloy containing alpha-uranium and gamma-uranium became 100 per cent gamma-phase when irradiated at a temperature at which it would otherwise have remained two-phase. There is a difference of opinion as to the mechanism involved in this change, but Dr. Pfeil favours the view that the presence of a body-centred-cubic nucleating agent will initiate the growth of a small region of body-centred-cubic structure among atoms which are cooling after the intense local heating in the track of a particle.

Dr. H. M. Finniston, head of the Metallurgy Division of the Atomic Energy Research Establishment, spoke about radiation damage in uranium and the marked dimensional changes observed in irradiated specimens. It has been found possible to study the dimensional changes by using a thermal analogy, and, although the phenomena are entirely different, the analogue method has given valuable information. It centres around the alpha–beta change which occurs at 650° C. and consists of repeated thermal cycling between 600 and 650° C. When this method was applied to rod specimens prepared in different ways, some specimens bent, and others grew lengthwise or suffered severe surface wrinkling. These effects can be explained by considering how the different fabrication processes or treatments have affected crystal orientation in the rods, since uranium shows pronounced crystal anisotropy. The closeness of the analogy is demonstrated by the effect of pile irradiation on single-crystal specimens of uranium which grow in the direction of the preferred axis. Dr. Finniston discussed the possible forms in which nuclear fuel might be prepared in future. He also referred to the difficulties of studying the properties of plutonium, which has six phase changes against the three in uranium.

Dr. J. H. O. Varley discussed radiation damage in ionic solids with particular reference to the alkali halides and methods of evaluating σ, the ionization cross-section. The investigating tool used is the colouring of the halide crystals on irradiation[1,2]. The colouring can be partly bleached out by light and more thoroughly by heat. The 'temporary' colouring (bleached by light) corresponds to displacements of electrons in the lattice, and the 'permanent' colouring (fast to light) is associated with displacement of atoms. The measured cross-section determined from the number of permanent colour centres per c.c.

produced by a given bombardment is of the order 3×10^{-21} cm.^{2}. The cross-section calculated on the assumption that displacements are produced by direct collision with atomic nuclei lies between 5×10^{-23} and 10^{-22} cm.^{2}. The measured cross-section gives a lower limit to the value pertaining to the principal displacement mechanism because there is not necessarily a one–one correspondence between the number of displacements and the number of colour centres produced. Dr. Varley used the relation between the cross-section σ_p for a p-fold ionization of a given atom or ion and the cross-section σ_1 for a single ionization in the approximate formula

$$\sigma_p \sim \sigma_1 \left(\frac{\sigma_1}{A}\right)^{p-1}$$

where A is the 'area' of the atom. From the range–energy relation obtained experimentally, it appears that σ_1 is of the order 10^{-17} cm.^{2}; A can be taken as $\sim 10^{-15}$ cm.^{2}. By the substitution

$$\sigma_p \sim 10^{-17}(10^{-2})^{p-1}$$

since $\sigma_p \sim 10^{-21}$ cm.^{2}, the approximation gives $p = 3$ as the number of electrons stripped from one ion. It is thus indicated that the removal of three electrons from a given negative ion is a sufficiently probable process to account for the number of colour centres and, consequently, for displacements produced, if it be assumed that each one of these three-fold ionized ions is ejected from its lattice site and trapped at some other site in the crystal. The end-state can thus be halogen atoms in interstitial positions, trapped in positive-ion vacancies or at dislocations, and electrons trapped in the sites vacated by the halogen ions, these electrons giving rise to the colour centres. Dr. Varley concluded by remarking that vacancy pairs can lead to fast bleaching by acting as scavengers, but there is still much to be elucidated. J. F. Hinsley

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THE NATIONAL GEOGRAPHIC SOCIETY—PALOMAR OBSERVATORY SKY ATLAS

THE first section of the Palomar Sky Atlas has recently been distributed to subscribers. This Atlas is being prepared from a survey of the sky north of declination −27°, made with the 48-inch Schmidt telescope on Mount Palomar. This area of the sky has been photographed on 879 pairs of plates; each plate of size 14 in. × 14 in. covers an area of 7 × 7 degrees. The plate centres are separated by 6°, so that adjacent plates overlap by ½ degree.

Each field is photographed in two colours in immediate succession. The blue exposures are obtained on the Eastman 103*a*0 emulsion, with a wave-length range of from 3500 A. (the short-wave transmission limit of the correcting plate) to 5000 A., the maximum sensitivity being at about 4100 A. The red exposures are obtained on the Eastman 103*aE* emulsion, combined with a red 'Plexiglass' filter, with a wave-length range of from 6200 A. (the short-wave cut-off limit of the filter) to 6700 A., the maximum sensitivity being at about 6500 A.

The exposure times for each series were chosen to reach the faintest stars which can be recorded by the telescope under average observing conditions. These times were separately determined for each shipment of plates and range from 10 to 15 min. for the blue exposures and from 40 to 60 min. for the red. The photographic magnitude limit is 21·1 for the blue plates and 20·0 for the red. The magnitudes of stellar images on the blue plates are approximately on the same system as that of the international photographic magnitudes, and those of the images on the red plates are approximately on the same system as the red magnitudes of Kron and Smith. The differences between blue and red magnitudes of stars on the survey plates are approximately 1·6 times their international colour indices. Stars having an international colour index of 0·7 appear about equally bright on the blue and red plates. The scale of the plates is 67·1 seconds of arc per millimetre.

Each pair of photographs of a field was inspected for quality before being accepted for reproduction in the atlas. If one member of a pair was rejected, the area was re-photographed in both colours. Many fields had to be photographed several times before both plates were passed as acceptable.

The photographs were first reproduced as positive transparencies. The photographic prints are in the form of negative reproductions, because they alone permit of satisfactory preservation of the plate limit. The prints were made by the Graphic Arts Facilities of the California Institute of Technology. Care has been taken to ensure that the faintest details at the limits of the plates are reproduced even at the price of inadequate reproduction of bright objects, so that the images of faint stars, galaxies and nebulosities, which are beyond the reach of smaller instruments, are preserved.

After extensive tests and trials, Eastman Kodak Finegrain Positive glass plates were selected for the positive transparencies and Eastman Kodak Unicontrast double-weight paper for the negative prints. The contrast of the paper is gamma 2·0, practically independent of development. The original plates show considerable variation in background density, which depends upon the sky brightness. Original plates with background densities less than 0·3 and greater than 0·9 were found to give inferior results and were rejected. The most satisfactory reproduction was found to be obtained by printing all positives to a density of 1·4. The paper prints were found to be most satisfactory with a density of 0·2 or slightly higher.

On the back of each print is stamped the nominal position of the plate centre for epoch 1855. In the north-east corner of each photograph is a label giving the serial number of the plate, the date of the exposure and the 1950 co-ordinates of the field centre.

The survey was made financially possible by generous grants from the National Geographic Society, which provided the photographic materials and equipment, the salaries of the personnel employed on the survey, and the cost of producing two contact positives on glass of each survey photograph. The

observing time with the 48-inch Schmidt telescope required to obtain the survey photographs was made available by the Palomar Observatory of the California Institute of Technology. Approximately eight years of observing time (1949–56) will be required to obtain the negatives. The copyright for the Atlas is held by the National Geographic Society.

The Atlas has been made available at a price that covers only the cost of production and handling of the prints. The estimated cost was 2,000 dollars per set of 1,758 prints (879 blue exposures and 879 red exposures) if fifty copies were ordered and 1,600 dollars per set if a hundred copies were ordered. The actual price can only be established after the printing is completed. Cancellation of orders will be accepted if the estimated price is higher than 2,000 dollars. Only one printing of the Atlas is planned, and no orders could be accepted after October 1, 1954, when the reproduction was commenced.

The Atlas will provide an invaluable working tool for observatories that possess copies. The Franklin Adams Charts, which covered the whole sky but which were made from originals on blue-sensitive emulsions only and which did not reach nearly to such a faint magnitude as the Palomar survey, have for many years proved of great value for many purposes. The photographs in two colours of the present survey and the faint-magnitude limit reached are of special importance: it is readily possible, for example, to recognize red stars and blue stars by the comparison of the sizes of their images on the blue and red photographs, while for such studies as those of interstellar absorption and the distribution of faint galaxies the reproductions will prove most useful.

It is recommended that, in order to prevent damaging the prints when in use, they should be covered with glass plates. The most satisfactory illumination is with the light source low and to the rear.

In making this Atlas available and at a reasonable price, astronomy will owe a great debt to the National Geographic Society and to the Mount Palomar Observatory.

H. Spencer Jones

OBITUARIES

Prof. A. R. Radcliffe-Brown

With the death on October 24 at the age of seventy-four of Prof. Alfred Reginald Radcliffe-Brown, emeritus professor in the University of Oxford, comparative social anthropology has lost its leader and foremost exponent. An intellectual heir of Montesquieu, Comte and Spencer, he represented the theoretical tradition which culminated in Durkheim, flourished with the French sociological school and was submitted to the test of empirical field-observations by British anthropology.

Radcliffe-Brown read mental and moral science as a scholar of Trinity College, Cambridge, and he worked with both Rivers and Haddon. At the age of twenty-six, after his election to the Antony Wilkin studentship in ethnology, he carried out research among the Andaman Islanders. His book under that title, completed in 1913 and published in 1922, is a brilliant analysis of ritual and of social organization. Together with the account of the Cambridge expedition to the Torres Straits and with Malinowski's "Argonauts of the Western Pacific", it inaugurated a new departure and pointed the way to the intensive field-work characteristic of modern anthropology. Apart from a number of important articles, this pioneering work marked Radcliffe-Brown's principal contribution to the field-study of primitive peoples. This was due mainly to his conception of social anthropology as a natural science of society and, within this discipline, to his personal attraction to inquiries aiming at the establishment of general principles.

Radcliffe-Brown propagated his views with zeal, and this left him with little time for field-investigations. He was appointed the first professor of social anthropology in the University of Cape Town (1921), head of the newly created Department at Sydney (1926), where he founded and edited *Oceania*, and professor at Chicago in 1931. Between 1937 and 1946 he occupied the newly created chair at Oxford, where he was a Fellow of All Souls, which had taken a leading part in its establishment. He also taught social anthropology at Cambridge, London, Birmingham, Pretoria, Johannesburg, Yenching, São Paulo, Alexandria, Manchester and Grahamstown.

A man of distinctive appearance, he combined a natural charm of manner, kindness to his colleagues and generosity to his juniors with an innate reserve which, at times, bordered on aloofness. He was happiest and most relaxed in the social climate of a 'salon', where he could discuss with equal verve an exotic recipe or his personal conception of Confucian philosophy.

Radcliffe-Brown was by temperament, method and necessity a thinker rather than an observer, a conversationalist, lecturer and essayist rather than the writer of lengthy treatises. He wrote with *litotes* and crystalline clarity, and his essays on kinship, taboo, primitive law and social structure have proved invaluable in helping to lay the anthropological foundations of the subject; and they are indispensable in its present-day teaching.

J. G. Peristiany

Dr. G. Placzek

Dr. George Placzek, of the Institute of Advanced Study, Princeton, who died at Zurich on October 16, was born in 1905 in Brunn (now Brno, Czechoslovakia). After studying theoretical physics in Vienna and Prague, he moved around Europe, working in Utrecht, Leipzig, Copenhagen and Paris, among other places. He spent a year at the Hebrew University, Jerusalem. In 1938 he went to Cornell University, and later worked on atomic energy at Cambridge, Montreal and Los Alamos. After two years in the research laboratory of the General Electric Company at Schenectady, he joined the Institute for Advanced Study in Princeton in 1948. He married in 1943.

Placzek's earliest major work was on the theory of the Raman effect, on which his review article became a classic. This led to a study of molecular rotational states, then a fruitful tool for determining nuclear spins. Later he turned to neutron problems. With O. R. Frisch he first proved that resonance-levels for neutron capture have extremely low energies. In collaboration with others, he helped to clarify the dispersion formula for nuclear reactions. Then came a study of the slowing-down of neutrons, which was started for its intrinsic interest, but proved of great importance for work on atomic energy. This led to study of the integral equations of neutron multiplica-

tion summed up recently in a book he wrote with K. M. Case and F. de Hoffmann. Since the end of the Second World War, his main interest has been in the scattering of neutrons by solids and liquids, which is important both for its contribution to neutron physics (it made possible the interpretation of experiments on neutron–electron interaction) and for its application to the study of solid state.

In each field his work was characterized by a penetrating thoroughness. He would not leave a problem so long as there was an important difficulty unsolved or a major relation not thought out. He always used simple techniques where possible, and usually used symmetry principles and classical laws for results where others might have tried much more elaborate methods.

His standards were high, and he had no patience with slipshod arguments either in his own work or in that of others. He did not suffer fools gladly, and this is probably why he had no enthusiasm for teaching, and had only a few pupils. But to those, and to others on his own level, discussions with him were always inspiring.

But what will be remembered of Placzek above all was his personal charm, his width of intense interest and his erudition, his understanding of people, and his integrity. He would have no more patience with slackness of moral principles than with sloppy mathematics, and he would not pay attention to the effect his principles would have on his personal convenience.

In his later years he was much troubled with ill-health, and for much of the time he would not have been able to keep his work going but for his iron determination, and for the care, and the vitality, of his wife.

R. E. Peierls

NEWS and VIEWS

British Cotton Industry Research Association: Dr. F. C. Toy, C.B.E.

The Council of the British Cotton Industry Research Association has announced that Dr. F. C. Toy will be retiring from his position as director of research at the end of this year. He was first appointed in 1944, having previously served for thirteen years as deputy director under the late Sir Robert Pickard. During his directorship, the Shirley Institute has expanded considerably to meet the increasing and changing demands of the industry it serves, and it is due largely to his wise and able direction that, by the quality and value of its work, the Institute is now generally recognized in industrial and scientific circles alike as the leading textile research association in the world. Although the main feature of the advances made under his influence has been the wider appreciation and utilization in the Lancashire textile industry of the practical results of research, he has remained true to his conviction that technological advances must ultimately be based on fundamental research, and he has ensured that a steady flow of such work has been maintained. This is reflected in the fact that the scientific standing of the Institute was never higher than it is to-day. Dr. Toy has the gift of stimulating interest and enlisting the support not only of those working under him, but also of those with whom he comes in contact, and it is not surprising, therefore, that he has won the respect of his staff, and of men at all levels in the Lancashire industry. The national importance of his work was recognized by the award of the C.B.E. in 1947.

The heavy responsibilities of his office have not lessened Dr. Toy's interest in his own subject of physics, and throughout his career he has taken an active part in the affairs of the Institute of Physics, culminating in his appointment as president for the period 1948–50. He has also taken a leading part in the activities of the well-known Manchester Statistical Society, of which he was the president during 1951–53. Although Dr. Toy leaves the Institute to the care of a younger man, he himself is undiminished in vigour of mind and body, and while one sympathizes with his desire to relax a little, one hopes that the great services he is yet able to render both science and industry will not be lost to the country.

Dr. D. W. Hill

Dr. D. W. Hill, who succeeds Dr. Toy as director of the British Cotton Industry Research Association, joined the staff of the Shirley Institute in 1937 and was appointed deputy director in 1944; and it is a source of pleasure to the industry and to the staff of the Institute that he will be able to continue and extend the work which he has shared with the director for the past twelve years. Dr. Hill was born in Bristol, and is a chemist by training, having graduated from the University of Bristol with first-class honours in chemistry in 1924. After academic work in Liverpool and three years in the research laboratories of Messrs. Boots Pure Drug Co., Nottingham, he spent three years with a Commonwealth Fund Fellowship first at the University of Illinois and then at the Rockefeller Institute. Then came a year in the University of Bonn, followed by two years as special lecturer in chemistry in the Universities of Bristol and Exeter.

With this background of academic and industrial research, Dr. Hill was appointed to an administrative position at the Shirley Institute in 1937; but in 1940 was seconded to the Cotton Control, working in Manchester and London, and also for a time in the United States. He returned to the Shirley Institute in 1944 as deputy director. Dr. Hill's two books, "The Impact and Value of Science" (1944) and "Co-operative Research in Industry" (1946), are well known, and prove his complete faith in the value of co-operative research as it has been developed in Britain. He is fully convinced of the need for the carrying out of fundamental research by a research association serving what is still largely a craft industry, but is also very conscious of the need to apply the results of such research as quickly as possible to the special requirements of that industry. These are difficult times in Lancashire, but it is Dr. Hill's conviction that the greater the difficulties the better the opportunity for proving the value of scientific and technological research.

Thomas Graham (1805–69)

Thomas Graham, whose discoveries in chemistry and physics had far-reaching effects on modern physiology, was born at Glasgow one hundred and fifty years ago on December 20, 1805. He studied

chemistry at the University of Glasgow under Thomas Thomson, graduated M.A. in 1824, and in 1830 became professor of chemistry at the Andersonian College. In 1837 he was appointed to the chair of chemistry at University College, London, and in 1855 he succeeded Sir John Herschel as Master of the Mint. Graham's name is attached to a tube plugged at one end with plaster of paris, which he used in his experiments on the molecular diffusion of gases (1829–31), and to his famous law. Separating animal and other fluids by dialysis, he distinguished between colloids and crystalloids; he also established the polybasic nature of phosphoric acid and noted the formation with alcohol of certain salts, which he called alcoates and which he observed to be analogous to hydrates. Graham possessed a lively mind, though his body was feeble, and he led a full and busy life. He was vice-president of the chemical jury at the Great Exhibition of 1851 and assisted in various inquiries ranging from the ventilation in the House of Commons and London's water supply to methods of gun-casting. At the age of thirty-one he was elected a Fellow of the Royal Society and was awarded Royal Medals in 1838 and 1850. In 1840 he became the first president of the Chemical Society, which he had helped to found, and six years later first president of the Cavendish Society. His "Elements of Chemistry" (1842) was long a classic. Graham died on September 11, 1869, at the age of sixty-four.

Gregor Johann Mendel

Prof. E. O. Dodson, of the University of Notre Dame, United States, has been fortunate enough to obtain a transcript of material on the life and work of Mendel taken from the archives of Mendel's monastery and of the Augustinian Order in Rome. The material was collected during the 1930's under the direction of the Right Rev. F. W. Howard, Bishop of Covington, Kentucky, and was entrusted by him to Sister M. Julitta, of Villa Madonna College (*Scientific Monthly*, 81, No. 4; October 1955). Using this material, Prof. Dodson has compiled a fascinating account of Mendel's early life and education, his training and monastic work in the monastery of Brünn, his election as abbot, and his unswerving endeavours to discover natural laws. The article also throws new light on the rediscovery of Mendel's work by de Vries, Correns and von Tschermak.

Noise, Vibration and Health

In the House of Commons on December 2, Sir Lionel Heald introduced a debate on the effect of noise and vibration on the health, well-being and efficiency of the nation, and urged the Government to give careful attention to research and education in this field, and to the need for more effective measures for the protection of the public. Tribute was paid by Sir Lionel, and by other speakers, to the immense amount of work which has been done in this field by the Building Research Station, and, on the medical side, by Dr. Littler and others at King's College Hospital; but it was urged that full advantage is not being taken of available knowledge. Mr. R. Bell, in seconding the motion, besides directing attention to the scope for administrative action and the need for some amendment of the law, suggested that Ministers responsible for departments which are the main offenders should insist on departmental programmes of research and education, and in particular urged that the definition of noise should replace vague terms such as 'reasonable and practicable'. Replying for the Government, the Joint Under-Secretary of State for the Home Department, Sir Hugh Lucas-Tooth, agreed that responsibility must rest with individual departments, and he advised the House to accept the motion. The control of exhaust noise from motor-vehicles is partly in the hands of the police, with whom man-power is a major difficulty, and partly a technical problem between the Ministry and the manufacturers. As regards aircraft, a new principle embodied in the Conway engine is claimed to effect a further reduction in noise, and in the view of the Minister of Supply, technical effort in this field should be directed to the problem in connexion with new types of aircraft. Sir Hugh also referred to the study of vibration caused by passing aircraft, undertaken by the Building Research Station, to the attention being given to the prevention of noise in hospitals and to the investigations of the effect of noise in factories made by the Industrial Health Research Board.

Thermonuclear Explosions

Following the broadcast from Moscow reported in the press that Soviet Russia is willing to discontinue hydrogen bomb tests by common agreement, the Government has been repeatedly questioned in the House of Commons on the subject. On November 30, in reply to Mr. Attlee, the Prime Minister stated that the Government had had no communication on the subject from the Soviet Government, but was ready to discuss these matters at any time. Sir Anthony commented that the reported statement might have appeared in a better light if it had been made before the recent Soviet explosion, and added that in any such discussions regard would have to be paid to the number and nature of the tests which each country had already made, as well as to those proposed. He also said that it remained the view of the British Government that a comprehensive disarmament agreement is the only final solution to these problems. When pressed by Mr. Attlee on that day, the Prime Minister did not, however, deal with the fundamental reason causing concern over the continuance of such tests, namely, the possible biological effects of the resultant radiation, or with the fact that no system of inspection is necessary to ensure that thermonuclear tests are not made in spite of undertaking to discontinue them, because such explosions can be detected over a wide area. These points were raised on December 1 in a question asking the Prime Minister to propose to President Eisenhower and Marshal Bulganin a cessation of all nuclear explosions pending the report of the United Nations Commission which is considering the effects of radiation. There was also on the notice paper a motion regretting the continuance of such tests, and expressing the belief that the tests in themselves involve a danger to the human race and requesting the Government not to proceed with such tests. On December 6, in reply to further questions, the Prime Minister suggested that we should await the report on nuclear radiation from the Medical Research Council, which is expected within two or three months, and also one from the United States National Academy of Sciences. He also said that the Government has no intention of departing from its decision to manufacture the hydrogen bomb, and it still regards manufacture and possession of the hydrogen bomb as a deterrent to war. While willing to discuss methods of regulating and limiting test

explosions which take account of our position as well as that of other countries, the Government is not prepared to accept agreements which would put the United Kingdom in a position of decisive inferiority to other great Powers and one not justified by our scientific knowledge and resources.

Gift to the University of Leeds for a Research Institute of African Geology

The Anglo-American Corporation of South Africa, Ltd., has recently given £100,000 to the University of Leeds for the foundation of a Research Institute of African Geology under the direction of Prof. W. Q. Kennedy. The Research Institute will be an integral part of the Department of Geology, of which Prof. Kennedy is head, and will have as its primary objects fundamental research into the origin of mineral deposits generally and the study of African geological structure in particular, and the training of postgraduate research geologists by means of active field-work in connexion with problems of African geology. Both research fellows and post-graduate research students will work on the complex problems of rock constitution, tectonics and mineral distribution in various parts of Africa. The field sessions in Africa will alternate with periods of laboratory work in Leeds, where the Department of Geology is already well equipped to undertake such work and where an additional building now being converted for use by the Department will help to house the Research Institute. By this means it is hoped to gather information both on the interpretation of continental structure and the determination of the factors which control the distribution of minerals of economic value. Prof. Kennedy has been concerned for some years with geological problems in various parts of Africa, and during 1951 and 1952 led expeditions to Mount Ruwenzori (16,794 ft.) on the border of Uganda and the Belgian Congo. These expeditions, which included members of the Colonial Geological Survey, the British Museum (Natural History) and the University of Leeds, have resulted in a new interpretation of the structure of that area.

Mining, Geological and Metallurgical Institute of India

Next January, the Mining, Geological and Metallurgical Institute of India will celebrate its golden jubilee. At the turn of the century, the need for scientific development and utilization of the mineral wealth already discovered in India by geologists was beginning to be realized by the pioneers in the field of mineral industry. At that time, there was no technical association in the country specifically devoted to the promotion of study and research in geology, mining and metallurgy. Conscious of the need for such an organization, and one that would also safeguard the interests of the industries and personnel concerned, a number of leading mining engineers, geologists and industrialists founded the Institute in January 1906. From its inception the Institute has played a part of ever-increasing importance in guiding and developing the technical advances pertaining to geology, mining and metallurgy in India. To celebrate the fiftieth anniversary, the Institute has arranged for an exhibition of modern mining and metallurgical equipment and a programme of visits to coal, manganese-ore, iron-ore, mica, and oil fields, manufacturing and industrial centres, and dam sites. These will be held in January immediately after the Industries Fair at Delhi, and just before the meetings of the Indian Science Congress at Agra. The Institute will welcome members of the mining, geological, metallurgical and allied engineering professions, and of learned societies and related technical organizations in other parts of the world. Further information can be obtained from the headquarters of the Institute at 27 Chowringhee, Calcutta 13.

Indian Council of Ecological Research

Following a resolution made by the Government of India, the Indian Council of Ecological Research has been founded. Its main objectives will be to study Indian vegetation with the view of collecting basic data on desert and flood control, forestry, soil conservation, agriculture, wild-life management, nature conservancy and pasture management. The founder-chairman of the Council is Shri C. R. Ranganathan, inspector-general of forests to the Government of India. The Council has recently published the first number of its *Bulletin* (1, No. 1; October 1955. Indian Council of Ecological Research, New Forest, Dehra Dun). This number contains a statement on the vegetation types of India issued at the symposium organized by the Indian Botanical Society held at Baroda during January 1–2, 1955, which led up to the Government's resolution. The terms of reference of the new Council are also included, together with a personal note on its founder-chairman. G. S. Puri, secretary of the Council, contributes a paper on the aims and objectives of ecology, and there are two short papers by Prof. W. H. Pearsall (London) and E. H. Graham (Washington).

Comets and Climatic Changes

In a paper entitled "Évidences Cométaires des Variations des Climats" (*Bull. Astro. Inst. Czechoslovakia*, **6**, No. 1; 1955), F. Link and Z. Linková deal with statistical research relating to the discovery of comets, correlated with solar activity. They have found that the annual number of comets discovered varies in the course of the solar cycle of eleven years. This variation is inversely proportional to rainfall, with two maxima during the eleven years, according to Helman's investigations, and more recently it has been found that the number of comets discovered during a cycle is greater in the even than in the odd cycles. The numbers of comets discovered between 1755 and 1953 are arranged in cycles 1–18, and then the mean number of discoveries per year in the successive cycles is given separately for even and odd cycles. The influence of the meteorological conditions on the observations of comets is shown by means of a graph. Solar activity being greater during the odd cycles, the circulation in the terrestrial atmosphere is increased, and in consequence observations become more difficult; as a result of this, there is a decrease in the number of comets observed.

This close connexion between the number of comets discovered and the meteorological conditions (the latter depending on solar activity) led the authors to carry out investigations on climatic variations since 1611, and the principle underlying this research is based on the assumption that the number of comets discovered is a function of three factors: the cosmic factor, that is, the actual number of comets that approached the Earth; the climatic factor, or the atmospheric conditions in civilized countries, which only need be included, as observations of comets in

uncivilized countries would be useless for statistical purposes; the social factor or human activity (in particular, astronomical activity) in civilized countries. While the first factor can be regarded as constant, the second would increase in a more-or-less continuous manner in time, and the third would be revealed in the slope of the curve $N = f(A)$, N being the number of comets discovered from zero year up to the year A. Both these quantities have been taken from a catalogue by Baldet ("Ann. Bur. Long", Supp. 1950), and a searching analysis of the results leads to certain conclusions on the meteorological conditions between the years 600 B.C.–A.D. 1740. A comparison is made between these and the data given by C. E. P. Brooks in "Climate through the Ages", covering about a thousand years up to comparatively recent times, and there is a close accordance between them. The Czechoslovak workers hope to carry out further investigations on the subject.

Imperial Forestry Institute, Oxford: Report for 1953–54

In an introduction to the thirtieth annual report of the Imperial Forestry Institute, Oxford, for 1953–54 (pp. 29; 1955) there is a good résumé of the work of the year. The number of students, particularly in the graduating class and in the research group, naturally varies from year to year; it was below normal during the year under review, but the report states that there would be an increase in the following year. A noteworthy feature of 1953–54 was that practically none of the new graduates sought employment either with the Forestry Commission or in the Colonial Forestry Service. They showed a preference for careers in private enterprises in Britain or Canada. Forestry employment in many of the Colonies is in such an uncertain position that the preference for a safe job is not surprising, though rather sad. Forestry probationers from overseas still go to the Institute; of the ten men who obtained the forestry degree, one was a Colonial forest probationer and returned to his Colony, one was a New Zealand forest scholar and has returned home, and two have gone back to Canada. Sixteen officers of the Colonial Service attended the forest officers' course, coming from Nigeria, Tanganyika, Northern Rhodesia, Sierra Leone, Kenya, Uganda, North Borneo and Fiji. The special Indian course has not yet grown to maturity; but two forest officers attended it, one from India (Bengal) and one from Pakistan (Punjab). The practical courses on the Continent have increased both in number and variety, and are arranged for the varying types of students attending the Institute. The work of the different branches of the Institute is discussed, and the report as a whole furnishes evidence of the value of the Institute to British forestry in its widest sense.

Crystallographic Symposia in Madrid

The International Union of Crystallography is holding a symposium in Madrid during April 2–7, 1956, on "Structure on a Scale between the Atomic and the Microscopic Dimensions". As well as the symposium, the Union is organizing an open meeting of the Commission on Crystallographic Apparatus and also a series of meetings on crystallographic teaching during April 3–6. Details of the programme will be published in *Acta Crystallographica*; but the main topics are: analysis of material from a world-wide survey; apparatus and books for teaching crystallography; and the teaching of crystal physics, crystal geometry, structure analysis, mathematical techniques and machines. Short papers for circulation prior to the meeting should be submitted by February 1, all communications being sent to the secretary, Dr. H. Judith Grenville-Wells, Chemistry Department, University College, Gower Street, London, W.C.1. Those who wish to submit papers should send the titles and abstracts by January 1 to the chairman of the Programme Committee, Prof. A. Guinier, Conservatoire National des Arts et Métiers, 292 rue Saint-Martin, Paris 3e. Further information on the symposium can be obtained from the Secretario del Comité del Symposium de la Union Internationale de Cristallographie, Instituto de Fisica, Serrano 119, Madrid.

Animal and Human Diseases in East Africa: Conference in Kampala

The East African Medical Research Scientific Advisory Committee will be holding a "Zoonoses Conference" in Uganda at Makerere College, Kampala, during January 11–13, under the presidency of Mr. H. Binns, director of the East African Veterinary Research Organization, Muguga, Kenya. The first day will be devoted to the general pattern of both human and animal diseases in East Africa and their relation to the fauna, particular attention being paid to kala azar, plague, relapsing fever, rabies and Q fever. During the following two days there will be four symposia at which will be considered brucellosis, helminthiasis, viruses and trypanosomiasis, respectively. The conference secretary is Prof. J. N. P. Davies, Pathology Department, Makerere College Medical School, P.O. Box 2072, Kampala, Uganda, to whom all correspondence should be addressed.

Announcements

The Chemical Society is offering a Corday–Morgan Medal for 1954 which, together with a prize of 200 guineas, is open to persons of British nationality, less than thirty-six years old, for published work in experimental chemistry. Applications or recommendations for the award should be made before December 31 to the Chemical Society, Burlington House, London, W.1.

The Radio Industrial Council is again offering this year up to six premiums of 25 guineas for articles which are likely to enhance the reputation of Great Britain in radio, television and electronics. Articles published in journals circulating exclusively to members of a trade or in privately published journals of professional institutions or learned societies will not be eligible. In addition, the author must not be engaged full-time in technical writing. Entries, which must include five copies of the article concerned, should be sent before December 31 to the Secretary, Radio Industry Council, 59 Russell Square, London, W.C.1.

A series of natural-history lectures and films for junior audiences, 10–16 years of age, will be given at the British Museum (Natural History), South Kensington, London, S.W.7, during the Christmas holidays, starting on December 27 and continuing each day until January 7, Sundays excepted. The lectures will be free and without booking. Programmes are available on application to the inquiries desk or on written application to the guide lecturer at the Museum.

LONDON RESEARCH STATION OF THE GAS COUNCIL

OPENING OF NEW LABORATORIES

ON November 18, Sir Robert Robinson formally opened new laboratory buildings at the Fulham works of the North Thames Gas Board which provide additional accommodation for pilot plant and chemical engineering experimental work. Together with the older buildings, these laboratories now constitute the Fulham Laboratories of the Gas Council's London Research Station.

Prior to the nationalization of the gas industry in 1949, there existed two main research establishments in Britain concerned with the production and use of gaseous fuels. These were the research department of the Gas Light and Coke Company started in 1924, and the Gas Research Board, which was set up in association with the Department of Scientific and Industrial Research in 1939. After vesting day, the Gas Council assumed responsibility for research in the industry, and it was decided to keep the former Gas Light and Coke Company's laboratories at Fulham in action as the London Research Station, and to set up a new research station in the Midlands to replace the Gas Research Board.

The London Research Station now consists of two groups of laboratories. Those situated at Fulham gas works are concerned with the manufacture and purification of gas, and with the recovery of by-products. Those at Watson House, on a site adjoining the works, are devoted to the use of gas in appliances of all kinds. The station is operated by the North Thames Gas Board on behalf of the Gas Council.

The laboratories at Fulham were originally opened in 1928 and at the end of the War had expanded into some temporary buildings which were used largely for pilot-plant experiments. The new buildings provide proper accommodation and facilities for this type of work. It is thus possible to carry out a research programme which covers a suitable range of small-scale, analytical and pilot-plant experiments together with design work in the chemical engineering field. Most of the new space is occupied by three large laboratories intended for pilot plants of small and medium size and for work in connexion with full-scale tests on plant in actual operation at any of the works of the North Thames Board. In addition, there are offices, lobbies, workshops and stores.

The older buildings, which were also open to inspection by visitors on November 18, contain four large laboratories which are devoted respectively to physical chemistry, to analytical operations, to by-products chemistry, and to problems arising from the construction and maintenance of gas-making plant. There are also offices, workshops, stores, several small laboratories for special purposes such as X-ray equipment or spectrographs, and a library.

The London Research Station is fortunate in that it can make full use of the extensive engineering, stores and workshop facilities of the Board. It is also customary for large pilot-plants to be installed at one or other of the Board's twenty-one gas-making works.

The overall programme of research authorized by the Gas Council is shared mainly between the London Research Station and the Midlands Research Station at Solihull; but work is also carried out in the laboratories of the South Eastern Gas Board, by the Fuel Department of the University of Leeds, and by other research associations to which the Gas Council subscribes. This programme falls into eleven main sections, concerned respectively with the manufacture of coal gas, the production of water gas and oil gas, the cooling and washing of gases, the removal of sulphur compounds, the recovery of by-products, the construction and maintenance of gas-making plant, flame and combustion, domestic and industrial heat services, ventilation and flues, refrigeration, and the provision and use of solid smokeless fuels.

Owing to the growing shortage and increased cost of good gas-making coals, some of the most important problems concern the production of gaseous fuels from low-grade coals and oils. Experiments on these problems were not on view at Fulham as they have reached the stage where the pilot plants have to be installed on a works site, or where the work is being done at the Midlands Station.

Among the items which were seen during the tour of the Fulham laboratories, particular interest is attached to four, which are concerned with the biological oxidation of aqueous effluents, the removal of sulphur compounds from gaseous fuels, the search for improved refractory materials, and studies in mass-transfer and heat-transfer processes.

During the purification of gases produced from coal, aqueous condensates are always obtained in association with tar. These liquors contain valuable substances such as ammonia and phenol, which are largely recovered; but small quantities of impurities always remain to make the final effluent harmful to vegetable or animal life in rivers or streams. In order to destroy the traces of phenols and ammonium thiocyanate which are present in these liquors, biological treatment, apart from disposal in sewage treatment plant, is being investigated and a considerable degree of success has already been reached in the search for suitable cultures.

Crude fuel gases always contain sulphur compounds, notably in the form of hydrogen sulphide, and efforts are being made to replace the conventional dry-box purifier which is used for its removal by a process depending on liquid reagents. Any success in this direction might also involve the production of elemental sulphur by a catalytic process, and an investigation into the physical properties of catalysts is associated with this section of the programme. Interest in catalysts is also extended to those used for the decomposition of organic sulphur compounds in gases.

The carbonization of coal in continuous vertical retorts is a process with a high thermal efficiency and several other attractive features; but conditions in the retorts are so severe that the life of the refractory materials used in their construction is relatively short. Much of the damage arises at the time when carbon deposits are burned off the brickwork at intervals, and a search is being made for refractory materials which will resist this disruptive action. As a contribution to this search, the mechanism of the deposition of carbon and of its removal by com-

bustion is being investigated in high-temperature experimental furnaces.

Many processes in the gas industry involve mass and heat transfer. For example, the cooling of gas is a process of heat transfer with simultaneous mass transfer of water vapour from the gas to the condensate film. Much original work on this subject is done by the chemical engineers of the staff of the laboratory. The removal of impurities such as ammonia from gas involves washing processes in which the type of packing in the scrubber is important. Pilot-plant studies of grid and ring packings have led to improvements in the design of full-scale plant.

The gas industry in Britain is at a stage where far-reaching changes in its techniques are needed, and the Gas Council's research stations are fully occupied with the experimental work on which new production methods will be based.

MYXOMATOSIS

THE Mammal Society of the British Isles held a symposium on myxomatosis at the London Zoo on November 5; Dr. L. Harrison Matthews took the chair.

Mr. H. V. Thompson (Ministry of Agriculture, Fisheries and Food) gave a general historical introduction and then described the main aspects of myxomatosis in Britain, pointing his description with evidence derived from other countries affected by the disease. Careful records have been kept of outbreaks of myxomatosis in Britain and, since the first notification of the disease in October 1953, it has spread over most of England, Wales and Scotland, although pockets of rabbits still survive in many places. In Continental Europe, the disease has spread from France to Belgium, Luxembourg, the Netherlands and Germany and, more recently, to Austria, Italy, Spain and Switzerland.

Since the first epizootic of myxomatosis in Australia during 1950–51, there has each summer been a similar epizootic, depending for its effectiveness mainly upon the presence and activity of adequate numbers of mosquito vectors. The natural spread of myxomatosis in Australia has been rapid, and, even when moving slowly, speeds of three miles a day have been recorded. In Britain, however, natural spread has been much slower, averaging three and a half miles a month in one carefully checked area. This slow spread, in an area where woodland mosquitoes were abundant but did not bite either wild rabbits or caged domestic rabbits, indicated that mosquitoes were not important vectors in Britain, and the rabbit flea has, in fact, been found to be the principal vector.

Mrs. G. Lane (Hon. Miriam Rothschild) considered the main vectors in her paper, stating that far too little is known of the natural history of the rabbit flea (*Spilopsyllus cuniculi*) and stressing the need for more research. In Northamptonshire all wild rabbits were infested with this flea, and a dense rabbit population is usually heavily infested. It may be found that in areas sparsely populated with rabbits, fleas are correspondingly few; it is possible that as the rabbit population falls, due to myxomatosis, so will the numbers of fleas on the remaining rabbits, a natural check being thereby offered to the disease. If a rabbit becomes infected with myxomatosis, then the infection spreads rapidly to all the fleas on that rabbit. The fleas are found to concentrate on the head and ears of the rabbit. It is interesting to note that when an infected flea bites a rabbit on the ear, the incubation period of the disease is much longer than after a bite on the head.

The grey squirrel flea (*Orchopeas howardi*), which can also be made to feed on rabbits, can become infected and be a reservoir of the virus for up to twenty days; the same may be true of other fleas.

The rabbit flea in Australia is a different species from that in Britain, and is a poor vector. Much of the work on vectors in Britain had been done by Dr. Muirhead Thomson, who was unfortunately unable to be present. The only mosquito so far implicated in the spread of myxomatosis in Britain is *Anopheles maculipennis atroparvus*. It has been found carrying infection in the same hutches as myxomatous rabbits. Unlike other British mosquitoes, *A. m. atroparvus* may live throughout the winter, feeding at intervals; but Mr. P. G. Shute considered that, since this mosquito rarely bites in the open, it is not likely to be an important vector. Dr. C. H. Andrewes pointed out, however, that the virus survives in the mosquito for as long as six months and, unlike many viruses, the titre of which falls initially and then builds up, the myxoma virus maintains its level in *A. m. atroparvus* with very little change. It is thus difficult to determine whether or not there is a multiplication of the virus in this mosquito.

Mr. J. R. Hudson (Ministry of Agriculture, Fisheries and Food) stated that myxomatosis is not readily transmitted by mechanical contact, such as wiping the nasal secretions from an infected rabbit on to a clean one, or by infected herbage. He also stated that animals of many different species, suspected of infection with myxomatosis, have been examined in his department; but with the exception of two hares there was no evidence of the disease affecting other animals. Five hares have been found in France with clinical myxomatosis, the disease being transmissible to rabbits but not to other hares.

Immune rabbits have been bred; but so far none of the progeny has shown any evidence of immunity. The residual rabbits in most parts of Britain are susceptible to myxomatosis; but in one area, part of Sherwood Forest in Nottingham, many rabbits have survived the disease and developed immunity. The strain of the virus is here much reduced in virulence, producing nodular lesions which contain fully virulent virus during the early stages but attenuated virus during the later stages. Attenuated field strains of myxoma virus have been recovered from several parts of Australia during the past two years, and this year have also been found in France.

The diet of foxes was discussed by Mr. H. V. Thompson in the light of stomach analyses being done in his department. He emphasized that the work is not yet complete; but that comparison with the results obtained by Southern and Watson fifteen years ago showed that there has been an increase of field voles, brown rats and vegetable matter in the diet of the lowland foxes, after myxomatosis. Similar changes in diet were also noted by Mr. H. N. Southern at Oxford. The small-mammal population declined considerably in the summer of 1955 following the arrival of myxomatosis, and the runways of mice and other small mammals were dug up by foxes. There has, however, been some recovery in the small-

mammal population during the past autumn. Southern also noted a very low reproductive-rate among the resident population of tawny owls on the Wytham Estate, Oxford, and there was some evidence that foxes, and also stoats, had produced smaller litters than usual this year.

Dr. N. W. Moore (Nature Conservancy) described very striking reductions in the breeding of buzzards, few birds having produced eggs in areas affected by myxomatosis; but in the areas to which the disease had not spread by spring of this year, the reproduction-rate was normal. There is also evidence that buzzards are moving about much more than previously, although spread in the range of buzzards has been taking place for some years.

Hares appear this year to be colonizing areas vacated by rabbits, and to be more frequently found in woods than hitherto; they also appear to be more abundant than in 1954, but it is too early to impute these changes to the effects of myxomatosis. The situation is also complicated by a number of introductions of hares into Cornwall, Pembrokeshire and elsewhere.

There is already good evidence of the recovery of the rabbit population in areas which were considered to be largely cleared by the disease. Southern stated that at Wytham Estate, near Oxford, only three rabbits' tracks were seen during the winter of 1954–55, whereas many thousands of rabbits were present before the onset of myxomatosis; now twenty burrows have been reopened. Similar reports came from several parts of Britain.

Dr. A. S. Thomas (Nature Conservancy) reported striking botanical changes following the great reduction of rabbits. He took photographic records of particular areas before the onset of myxomatosis, and compared these with more recent photographs. Detailed records of the changes have also been made since March 1954 along transects in ten places, mostly on declared or proposed Nature reserves on the chalk; the total length of these transects is more than 23,000 ft., and fifty point quadrats are recorded on every 100 ft. once or twice yearly. The early results of this method are very encouraging. The grasses are higher, there is much better ground cover and a greater range of species, especially of the more palatable grasses and clovers which were grazed by the rabbits. Woody plants, especially ling and gorse, which were closely grazed by rabbits, have made much growth; in the case of gorse the shoots have been up to 18 in. long in twelve months.

There has been not only marked vegetative growth, but also a wonderful show of flowers, both of the common ones like cowslip and rock rose and also of the less common orchids, which have appeared in profusion in places where they were not previously noticed, because rabbit grazing prevented flowering. One interesting result of the disappearance of rabbits has been the great profusion of ragwort in some places during the summer; the plants colonized rabbit-grazed turf, but rabbits also prevented many of them from flowering.

Many plants which have been relatively common in areas of intense rabbit infestation have owed their abundance to the fact that they are unpalatable or poisonous and could flourish when rabbits ate down and killed more palatable species. Such plants include viper's bugloss, hound's tongue, deadly nightshade, stinging nettle and elder, all of which flourished on the disturbed and manured soil around rabbit holes. It is too early to look for marked changes in these plants; but already elder bushes are suffering in some places from the absence of rabbits, because increased stocking with cattle to utilize the increased grass has resulted in the barking and killing of elder. Increased stocking should also control the growth of other woody plants which are appearing in grassland areas now that they are no longer being eaten back by rabbits.

Mention was made by Mr. H. N. Southern (Bureau of Animal Population, Oxford) of the great increase in tree cover on the Wytham Estate, Oxford; ash and particularly oak saplings are appearing where they were scarcely seen before.

Mr. W. Ives, scientific liaison officer in London of the Commonwealth Scientific and Industrial Research Organization, Australia, spoke of the remarkable changes which have occurred in the vegetation in Australia since the rabbit population was reduced, saying that grass is now growing well in places that had been virtually desert, and that, in some areas, land capable of carrying one sheep previously now carries two cows.

Kenneth M. Backhouse
Harry V. Thompson

BIOCHEMICAL AND MICROBIOLOGICAL RESEARCH IN HUNGARY: SOME IMPRESSIONS

A GENEROUS invitation to spend three weeks this summer as guest of the Hungarian Federation of Technical and Scientific Societies (METESZ) enabled one of a party of six British and four French scientists to see something at first hand of recent academic research in biochemistry and microbiology in post-war Hungary. Damage and losses suffered during the War, the economic and social revolution and the reorganization of academic research under the ægis of the greatly enlarged and reconstituted Academy of Sciences have resulted in big changes and considerable expansion in research programmes. At the same time, they have inevitably led to many administrative difficulties, and heavier teaching responsibilities (associated with an increase of more than four-fold in the number of university students).

Academic research is also still handicapped in many parts of the country by shortage of specialized equipment. The more complicated laboratory apparatus such as high-speed centrifuges, spectrophotometers, electron microscopes, etc., is not manufactured in Hungary and has to be imported from the U.S.S.R., Germany and Czechoslovakia. This means that such instruments are only rarely available. There have also been delays and difficulties in obtaining radioisotopes, which are now, however, beginning to arrive from the Soviet Union.

Hungarian biochemistry has suffered much from the departure of Prof. A. Szent-Györgyi, together with several of his most valued younger colleagues, to the United States in 1947. This gap, however, is gradually being filled by the younger generation of biochemists led by Academician F. B. Straub (a former pupil of Szent-Györgyi), director of the Institute of Medical Chemistry in the Medical University of Budapest, and by Prof. E. Szörenyi, head of the Biochemical Institute of the Academy. Straub's department of sixteen workers is devoted primarily to a study of protein synthesis. In spite of old and unsuitable accommodation (the city was

terribly damaged during the siege early in 1945 and much rebuilding is still needed), this group has been doing important work and has recently succeeded in demonstrating the production of amylase by a mitochondrial preparation from homogenates of pig and pigeon pancreas and the formation of pepsinogen by homogenates of gastric mucous membrane. Other work includes the study of induced penicillinase synthesis by protoplasts of *Bacillus cereus* (Dr. M. Kramer) and the development of a technique of reversible 'hæmolysis' of red blood cells (Dr. S. Manyay) whereby they are rendered temporarily permeable to adenosine triphosphate and other substances, without actual disruption of the cell membrane.

A group of young and enthusiastic protein chemists at the Biochemical Institute has a wide programme which includes (*a*) the study of scleroproteins, in particular the relationship between procollagen and collagen in mammalian skins and fish swim bladder (Dr. I. Komyat); (*b*) a comparative immunochemical investigation of serum albumens from horse, donkey and mule (Dr. F. Antoni); (*c*) an enzymological comparison of crystalline triosephosphate dehydrogenases from yeast, mammals and crustacea (Dr. P. Elödi); and (*d*) the specificity and speed of action of proteinases (for example, trypsin) on homologous and heterologous proteins (Mrs. G. Szabolcsi).

One of the most distinguished figures in Hungarian microbiological research is Academician G. Ivánovics, director of the Microbiological Institute in the Medical University of Szeged, who is well known to many British and American microbiologists. This University was moved from Kolozsvár when Transylvania was handed over to Roumania after the First World War. The buildings are relatively new, well designed and pleasantly situated in one main group in this attractive town of 100,000 inhabitants on the River Tisza. Prof. V. Bruckner, of Budapest, has recently succeeded in synthesizing a D-glutamic acid polypeptide, which Ivánovics has found to be chemically and immunologically similar to the polypeptide he originally isolated from the capsule of *Bacillus anthracis*. Ivánovics is also studying the properties of a high-molecular weight substance—'megacin'—isolated from *Bacillus megaterium* after ultra-violet irradiation, which appears to be a type of 'bacteriocin', specifically able to lyse cultures of *B. megaterium*. Other work in this Institute includes research on animal viruses, typing of influenza strains, etc., and some interesting studies by Dr. L. Alföldy on a bacteriophage of *Pseudomonas aeruginosa* having properties intermediate between those of a virulent and temperate phage.

Another medical university is in Debrecen—a quiet town of about the same size as Szeged 140 miles due east of Budapest, with important historical traditions (it was declared the capital of the short-lived independent Hungarian Republic during the war of liberation led by Lajos Kossuth against the Hapsburg dynasty a century ago). Its main university was founded in the fourteenth century only a few years after the University of Budapest; but most of the present buildings are comparatively new and the medical university was built during and after the First World War in a pleasantly wooded park on the outskirts of the town. It consists of well-designed separate buildings for each department and related hospital clinics, connected by a system of underground corridors. Here, in the Institute of Pharmacology under the leadership of Prof. T. Vályi-Nagy, a small group of microbiologists is studying antibiotics. An interesting new compound—'primycin'—produced by a species of actinomyces isolated from the intestine of the wax moth, has been crystallized and found to inhibit the growth *in vitro* of both *Mycobacterium tuberculosis* and *Staphylococcus aureus* at a concentration of 0·02 μgm./ml. It is unfortunately too toxic for general use, but some promising preliminary results are reported after local application in superficial infections. Among other work, the inhibitory action of streptomycin on growth of the organism which itself produces this antibiotic (*Streptomyces griseus*) is being studied by Dr. G. Szabó.

Back in Budapest, at the Institute of Microbiology of the Medical University, an opportunity was afforded of seeing a technically very well-produced film, shown by Drs. I. Juhász and J. Vadász, of the remarkable phenomenon of cell regeneration from an apparently acellular degenerated mass of granular protoplasm formed after treatment of a strain of *Salmonella enteritidis* with high concentrations of penicillin.

Finally, specific mention should be made of the Institute of Genetics in Budapest where, apart from other work on higher plant genetics, Prof. B. Györffy has recently established a microbiological section comprising five workers covering a wide range of subjects: (*a*) heterokaryosis in *Penicillium* (Dr. Igali); (*b*) streptomycin resistance in *Serratia marcescens*; (*c*) nucleic acid chemistry (Dr. Thomas); and (*d*) transformation, by deoxyribonucleic acid extracts, of *Rhizobium* species (Mrs. R. Balassa), using streptomycin-resistance and ability to form nodules on the alfalfa plant as genetic characters, which appear to be transmitted independently of each other. After early difficulties, not unconnected with the attitude to genetics prevailing five years ago, when Györffy's department was in danger of becoming a subsidiary section of the Agricultural University, his Institute is now being fully supported, as an independent research centre, by the Academy.

All this, of course, represents nothing more than a glimpse at some of the research work at present being done in Hungary. Although far better supported than before the War, academic research still suffers, perhaps, from the relatively greater emphasis laid on applied research—in industry and in the technical and agricultural universities. This is understandable—perhaps inevitable—in view of the determined efforts at industrialization of what was primarily an agricultural community. It shows itself, especially, in some shortages of specialized equipment and the great difficulties in obtaining technical assistants, who are attracted into industrial establishments by salaries up to twice those which they can earn in institutes of pure research (a problem not exclusive to Hungary).

Although excellent library facilities (which compare favourably in some cases with those provided in similar British research centres) have allowed Hungarian scientists to keep closely in touch with recent advances in the West, this cannot compensate for the rarity of direct personal contact. Unfortunately, during the past few years, opportunities for direct contact have been largely restricted to countries in Eastern Europe. One of the most lasting impressions obtained from this recent visit was the repeatedly expressed desire to re-establish closer contact with Western scientists. The more favourable political climate should make it easier to remove the obstacles still present (on both sides) to a freer exchange of

visits, and might perhaps even abolish some of the restrictions to normal trade relations which at present prevent the import of badly needed British scientific research equipment into Hungary. A conversation with Academician Bognár, general secretary to the Hungarian Academy of Sciences, gave grounds for hope that the Academy might actively support projects for a more liberal exchange of visits of individual scientists between Britain and Hungary in the near future.

Meanwhile, it is encouraging to learn that a party of Hungarian scientists has recently visited Britain, under the auspices of the World Federation of Scientific Workers and the British Association of Scientific Workers; and that METESZ is to repeat its group invitations (begun in 1954) to British and French scientists next year. METESZ and its hard-working and imaginative secretary (Dr. E. Valko) and assistant secretary (Mrs. Barbara Striker) are indeed to be congratulated on having taken one of the first steps to break the ice. M. R. Pollock

DEVELOPMENT AND WELFARE IN THE BRITISH COLONIES

THE schemes made under the Colonial Development and Welfare Acts, covering the period April 1, 1954–March 31, 1955, which are detailed in the latest return*, bring the total commitments for development and welfare schemes under the Acts to £123,402,271, and for research schemes to £12,908,139, of which £14,757,289 and £533,548, respectively, are for the year in question. Of this last sum, £133,157 is for agriculture, £83,767 for medicine, £54,413 for locust control, £47,589 for insecticides, £25,553 for social science, £9,042 for economic research, £6,795 for products research, £6,200 for fisheries and £2,250 for tsetse and trypanosomiasis.

Of the actual research schemes, £104,024 was for the establishment and maintenance for two years of the East African Scientific and Industrial Research Organization, a further £42,500 for the East African Medical Survey, £50,000 for the establishment and maintenance of the Colonial Road Research Section at the Road Research Laboratory, Harmondsworth, a further £37,750 for the maintenance of the Anti-Locust Research Centre and extra-mural activities, £31,483 for the purchase of buildings at Kavete for the East African Veterinary Research Organization, £22,329 to establish an Agricultural Research Station at Aden, £17,780 for sylvicultural research in Nyasaland, a further £16,365 to maintain the Ebini Livestock Experimental Station in British Guiana, a further £16,663 for the Desert Locust Survey and £14,390 for the maintenance of the Colonial Insecticides Research Unit at Porton.

In West Africa, £10,955 was provided for the establishment of a Standing Advisory Committee for Agricultural Research and a further £5,306 for the establishment of the West African Building Research Organization, as well as £4,500 for a social and anthropological investigation of the State of Gonja, Gold Coast. In East Africa, a further £8,100 was provided for control of coconut palm pests in Zanzibar; in the Western Pacific, a further £6,332 for investigation of means of controlling *Amblypelta cocophaga* and other coconut pests in the British Solomon Islands; in Sarawak, £4,300 for an investigation into the control of pepper disease; and in the West Indies, a further £4,230 for cytogenetical research on sugar cane and £6,780 for a pilot scheme for establishment of a Nutritional Research Unit in Jamaica.

Among the major development and welfare schemes of particular scientific interest are the following: in East Africa, a further £700,000 for the desert locust control campaign and £785,438 to intensify African agricultural development in Kenya during 1954–55; in Malaya, £408,250 for the construction of a road between Temerloh and Maran, linking the west and east coasts, £204,000 for the establishment of rural health centres, and £410,000 for the construction of a teachers' training college, at Penang in British Guiana, and a further £72,750 for geological survey, as well as £35,000 for aerial survey and £20,833 for hydrographic and hydrological surveys. In British Honduras, a further £38,075 was provided for the artificial regeneration of pine, £29,555 for rice investigation and £45,200 for afforestation of pine savannah. Among a series of grants to the University College of the West Indies are £10,000 for the establishment of a Department of Chemical Technology and a further £10,000 for scientific equipment. £11,450 was provided for rice research in the British Solomon Islands Protectorate, and £33,500 for an aerial survey of Fiji. In West Africa, besides £99,314 for senior staff housing for the Nigerian College of Arts, Science and Technology, a further £150,000 for road development in the Cameroons and various contributions to Fourah Bay College (including £27,000 for additional laboratory and library accommodation), a supplementary contribution of £3,763,351 to the Development Plan for Nigeria includes substantial grants, distributed over all the regions, for agriculture (totalling £615,113), general education (£527,828), technical education (£455,478), forestry (£83,315), leprosy control (£217,793), medical and health (£884,909), veterinary (£125,244) and fisheries (£38,437).

* Colonial Development and Welfare Acts: Return of Schemes made under the Colonial Development and Welfare Acts by the Secretary of State for the Colonies, with the Concurrence of the Treasury, in the Period from 1st April, 1954, to 31st March, 1955. Pp. 32. (London: H.M.S.O., 1955.) 1*s.* 3*d.* net.

ECONOMIC DEVELOPMENT OF BASUTOLAND, BECHUANALAND AND SWAZILAND

A WHITE Paper on the High Commission Territories of Basutoland, Bechuanaland and Swaziland* gives a concise picture of the economic development and social services in these three territories, to which since 1945 nearly £14,144,000 has been granted or earmarked. Of this, nearly £3¾ million was from Colonial Development and Welfare Funds available for 1945–56, and a further £3 million has been allocated under the 1955 Act for the period to 1960. The Colonial Development Corporation has embarked on projects in the Bechuanaland Protectorate and in Swaziland, for which capital sanction of £7,299,000 has been given; of this amount, £4,424,000 had been spent by the end of 1954, and, according to present plans, full development of these projects may involve expendi-

* High Commission Territories: Economic Development and Social Services. Pp. 20. (Cmd. 9580.) (London: H.M.S.O., 1955.) 9*d.* net.

ture of another £10 million, not necessarily all from public funds.

Reviewing the more important results of this investment, the White Paper emphasizes that, as a result of a campaign against soil erosion, the whole of Basutoland will be fully protected against erosion during the next few years; and it is also hoped that, by reclaiming existing dongas or gullies by damming and planting trees, the water-table throughout the whole of the lowlands will be raised, with much benefit to pasturage and crop yields. The agricultural techniques best suited to Basutoland are being determined at an agricultural experimental station at Maseru and at twelve sub-stations, and a complete catchment area is being developed intensively to demonstrate how better land-utilization can increase productivity as well as prevent soil erosion. Other measures have considerably improved the quality and value of the Basutoland wool clip, and, besides some improvement of the lowland road system, a road to continue sixty-eight miles into the mountainous interior is under construction and is expected to be completed during the next two years.

In the Bechuanaland Protectorate much effort has been given to the improvement of water supplies in the settled areas in the eastern part of the reserves, while attention has also been given to the improvement of the quality of the cattle as well as the control of foot-and-mouth disease. The opening of an abattoir and cold-storage plant in Lobatsi in October last year will enable producers of first-grade animals to sell their beasts in peak condition and help to prevent disruption of marketing arrangements caused in the past by outbreaks of foot-and-mouth disease. On one of two large cattle ranches established in the Protectorate, the Colonial Development Corporation has made available watering facilities and large areas of grazing to a co-operative body of cattle exporters for rearing young animals in better conditions. Better farming methods are also being demonstrated, and a geological survey has confirmed deposits of minerals such as copper, coal, asbestos and kyanite.

In Swaziland, where the territory's revenues have been doubled during the past few years, significant improvements over the whole field of African activity —agriculture, cattle, water supplies, health, hygiene and education—have been obtained by a rural development scheme in which development teams are concentrated on chosen areas. Under a native land settlement scheme, conservation farming, grazing control and efficient crop production are practised in model settlements under government supervision. Some 160,000 acres have been planted with pine trees, and the possibilities of irrigated farming are being explored. About 30,000 acres are already irrigable, and it is intended to irrigate some 30,000 acres in north-east Swaziland. In these projects a variety of crops, including rice, bananas, citrus fruit and vegetables, are already being produced, while an important livestock and dairying industry has done much to reduce the incidence of stock disease.

Although the first essential is to develop the wealth and resources of all three territories so as to increase their revenues and make possible a general improvement in the standard of living of their inhabitants, expenditure on medical services has also greatly increased, and further greatly needed improvements are planned. In Basutoland, where there is now one doctor to every 21,600 persons and one hospital bed to every 1,250, more accommodation is to be provided during the next five years for patients suffering from tuberculosis, and a new mental hospital is to be built, which will be open to patients from all three territories. In Bechuanaland there is now one doctor to every 17,000 persons, and one hospital bed to every 555, and efforts are being made to provide adequate facilities in rural districts. In Swaziland the objectives, for which more than £200,000 has been granted during the past ten years from Colonial Development and Welfare Funds, have included the eradication of malaria (incidence of which has been reduced from 5,750 cases in 1948 to 765 in 1953) and the expansion of medical services in the low veld to meet a redistribution of population.

Special interest is attached at the moment to the development of African education. In Basutoland, where most schools are run by missions with financial assistance from the Government, a ten-year educational development plan was formulated in 1946; by the end of 1954 more than three hundred schools had been erected, altered or repaired, and the Lerotholi Technical School, with accommodation for boarders, had been built. A further five-year plan is proposed for building an agricultural training school and six new junior secondary schools and to separate secondary education from teacher-training at the Morija training school. In Bechuanaland, two junior secondary day schools and two secondary boarding schools have been built, the percentage of qualified teachers raised from 40 per cent to 52 per cent and the average size of classes reduced from 56 pupils to 33. Under a further programme a new teacher-training college, a trade school and four new junior secondary schools are to be built and the Bamangwato College enlarged and run as a secondary school for the whole Protectorate. In Swaziland, where enrolment in schools has increased by 80 per cent during the past ten years, further developments are also contemplated beyond those for which grants exceeding £175,000 have been made since 1945 from Colonial Development and Welfare Funds.

PENTAGONAL SYMMETRY IN NATURE

IN the various papers and books on the nature of organic symmetry, there is surprisingly little comment on pentagonal or pentamerous forms. This is not because of a rarity of occurrence of objects displaying such characteristics, for, although not ubiquitous, five-part units are common in both animal and plant design. One of the reasons for such a situation is that the pentagon does not lend itself to readily understood physical and mathematical notions of utility and function as do the hexagon and equilateral triangle. None the less, several groups, including both animals and plants, have developed either a five-part symmetry as a whole or special structures with a five-part symmetry, and their significance has recently been discussed by C. M. Breeder, jun. (*Bull. Amer. Mus. Nat. Hist.*, **106**, Art. 3; 1955. Pp. 48; 1.50 dollars).

The number five and pentagonal designs have figured prominently in ancient mythology, magic and theology, and still exist in numerous present-day symbolic designs. Not the least interesting aspects of such considerations are found in some of the dynamic consequences of five-part symmetry. These con-

sequences extend into the behaviour patterns both of those organisms possessing it in some form and of those reacting in some way to designs of this order. Organisms as different as honeybees and men clearly show striking attitudes and responses with respect to this form of symmetry.

Breeder's studies were based on prominent and varied echinoderm fauna as well as a striking number of five-petalled flowers, such as *Hibiscus*. His findings show that pentagonal order is common in some groups and is absent in others; there is little casual or incidental occurrence. It appears as the basic pattern of flowers, of dicotyledons, of echinoderms, of the vertebrate body section, of the distal ends of tetrapod limbs, and of the oral armature of priapulids. Its occurrence elsewhere is not common but includes the following cases: the tarsi of half the superfamilies of beetles have uniformly five segments, the other half showing various reductions in the number of segments; the ancestrula of certain bryozoans is pentagonal, although all subsequent individuals are hexagonal.

Five-partness, where it appears, is held to with great rigidity, even when extensive evolutionary change has taken place. This does not seem to be the case to such a marked extent with other symmetries, as the coelenterates show; here the group is marked by a considerable symmetrical instability.

A PROJECTION INSTRUMENT TO AID IN THE DETERMINATION OF MESOMORPHIC AND POLYMORPHIC TRANSITION TEMPERATURES

By Dr. G. W. GRAY and A. IBBOTSON
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THIS instrument consists of a simple optical system to be used in conjunction with the electrically heated microscope block[1] for the measurement of mesomorphic and polymorphic transition temperatures in the range room-temperature to about 380° C. Such transition temperatures are determined[1] on a mounted specimen, which is inserted in the slide slot of the heating block so that, by means of the optical system, its image is projected on to a screen. The detail which can be seen in the image is very much less than when the sample is observed using a microscope; but it has been found that transitions can be observed with equal accuracy and facility. The projection of the image on to the screen has the advantage that the eye strain involved in carrying out large numbers of determinations of transition points is completely eliminated. This is of significance in any investigation into the effects of changes in chemical constitution on the mesomorphic behaviour of organic compounds[2].

Fig. 1 illustrates the constructional and optical details of the projector. The light source (*A*) is a 500-watt projection bulb, which is mounted vertically in a well-ventilated lamp housing. The light beam passes horizontally through an aperture (2 in.) and is reflected vertically downward by the mirror *B*, through a condenser *C*, a sheet of heat-absorbent glass *D*, the mounted specimen (*E*) in the heating block, a projection lens *F*, on to a mirror *G*, and from there to the screen *H*. Two sheets of 'Polaroid' (P_1 and P_2), 2 in. in diameter, the uppermost capable of rotation about a vertical axis, enable the sample to be viewed in normal or polarized light. Using a 4-in. focal length projection lens, and a distance of 20 in. from the screen to the mirror *G*, the $\frac{1}{2}$-in. diameter specimen provides an image of diameter $3\frac{1}{2}$ in.

The arrangement of this optical system relative to the instrument as a whole is also shown in Fig. 1. All parts are attached to two vertical steel tubes, 6 ft. long and 2 in. in diameter, carried on a stout wooden base, 18 in. square. The platform which carries the heating block is 8 in. square and is supported, at the two corners away from the main stand, by two pillars 23 in. long. A 6-in. square of $\frac{1}{4}$-in. thick asbestos is screwed to this platform, and through both is drilled a $\frac{3}{4}$-in. diameter hole. The heating block is arranged centrally over this hole. The 'Polaroid' (P_2), the projection lens, and the mirror *G* (4 in. × 3 in.) lie below this platform, and all three may be moved independently in a vertical plane. The superstructure above the platform, also

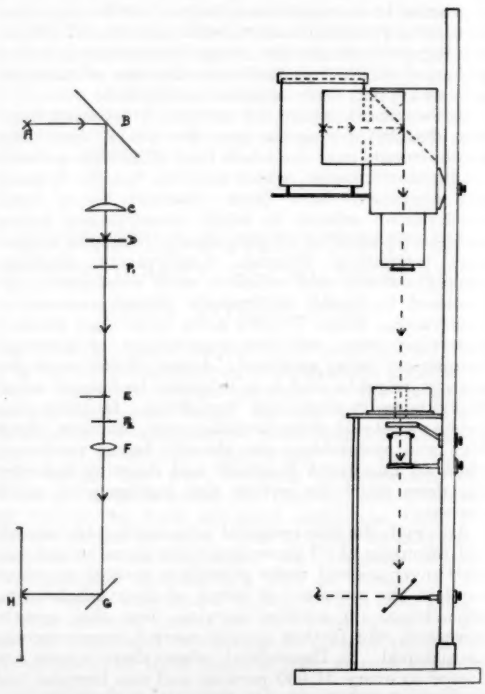

Fig. 1

movable in a vertical plane, consists essentially of two hollow brass cylinders. The first of these (10 in. long and 6 in. in diameter), containing the mirror *B*, is closed at the top and the 4-in. diameter hole at the bottom carries the condenser. A subsidiary cylinder, 4 in. in diameter and 4 in. long, screws in below this cylinder. Mounted in this cylinder is the heat-absorbent glass, and the lower end is closed by the rotatable 'Polaroid' P_1. This 'Polaroid' is mounted in a brass ring with a serrated edge which facilitates its adjustment, and carries a 0–360° scale. The other major cylinder (11 in. long and 8 in. in diameter) constitutes the lamp housing and is attached to the first cylinder by two brass sheets riveted to both cylinders. The gaps above and below are covered by brass sheet to eliminate the scattering of light. The base of the lamp housing is a 9-in. diameter disk which carries the lamp, but is held at least one inch clear of the cylinder base. The top of the cylinder is covered by a 9-in. diameter lid which is supported by brass strips about an inch above the cylinder top. These precautions were taken in order to ensure adequate ventilation of the lamp housing. The light beam passes through 2-in. diameter holes in the cylinders and thence to mirror *B*.

As a result of standardization against measurements made on the heating block in conjunction with a microscope, the following procedure was adopted for determination of melting points, mesomorphic and polymorphic transition temperatures. The nematic- or smectic-isotropic transition is taken as the temperature at which the last trace of anisotropic mesophase disappears from the image in polarized light. In the same way, the smectic–nematic transition temperature is that at which smectic characteristics can no longer be seen. In all cases, the above mesomorphic transition temperatures are reproduced when the sample is cooled. Similarly, melting points are given by the temperature at which all crystalline material vanishes from the image, and polymorphic transitions by the disappearance of one solid modification in another. [Aug. 30

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ACCELERATION OF ABSCISSION BY A FACTOR PRODUCED IN SENESCENT LEAVES

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NEARLY twenty years ago, La Rue[1] demonstrated that removal of the leaf lamina causes a rapid abscission of the petiolar stump; but if a small part of the blade is left attached to the petiole, abscission is retarded. He further showed that if indole-acetic acid mixed with lanolin is applied to the cut end of the petiole following removal of the lamina, then the effect due to the blade tissue is simulated since abscission is delayed. Other workers[2–4] have confirmed and extended these results, and many active plant growth-regulating substances are now known which can, like indole-acetic acid, retard abscission.

More recently, Addicott and his co-workers[5] have shown that if indole-acetic acid and certain other growth substances are applied to the petiole in a position proximal to the abscission zone, abscission may be accelerated. By means of tissue extraction followed by bio-assay[6], they have assessed the auxin content of the leaves and petioles of bean plants in different stages of development, and have shown that there is a gradient of natural auxin from leaf to stem, which falls as the leaf matures. On the basis of their accumulated evidence, these workers have suggested that abscission may be controlled by an auxin gradient across the abscission zone from leaf to stem. As long as this gradient is positive, abscission will not occur; but when the gradient falls to zero, either as a consequence of leaf senescence or removal of the leaf blade, separation will take place. When the gradient becomes reversed, following an increase in the proximal supply of auxin, abscission is accelerated.

Jacobs[7], in his comprehensive investigations with *Coleus*, has demonstrated that leaves, particularly those in the apical bud which produce the maximal amount of auxin, promote the abscission of nearby petioles from which the laminæ have been removed. He also showed that abscission of the petiolar stumps is accelerated if the apical bud is removed and replaced by lanolin containing indole-acetic acid, and concludes that the auxin produced in the apex is, in part, transported down the stem and acts as a source of proximal auxin.

Ethylene gas has long been known to accelerate the abscission of intact leaves; the production of ethylene by plant tissues is well established, and Gawadi and Avery[8] have proposed that a balance between auxin production and ethylene production may control abscission in the leaf. Although ethylene and indole-acetic acid may have opposite and antagonistic effects on abscission[9], proof of the existence of such a balance has not, so far, been obtained.

During the course of experiments on leaf abscission, carried out over the past three years at Oxford, it has become apparent that there is a further controlling factor, namely, that as leaves mature and reach senescence they produce a chemical substance or substances which have the property of accelerating the abscission of intact abscission zones.

This chemical factor was first extracted into agar from the distal pulvini of senescent primary leaves of *Phaseolus vulgaris* using the classical methods of diffusion employed by Boysen-Jensen and Went. The bio-assay is a modification of a method originally described by Addicott[10], and the following is a brief description of the procedure.

The distal pulvini are excised from the primary leaves of *Phaseolus vulgaris* var. Canadian Wonder, and are placed, proximal side down, on 0·03-ml. blocks of 2 per cent agar. Each pulvinus is left in contact with its agar block for twenty-four hours at 24° C. under conditions of high humidity. Each agar

Table 1. Average time in hours for abscission of bean explants when (*a*) agar blocks containing diffusates from young or abscinded pulvini are applied to the pulvinar end; or (*b*) whole pulvini are sealed with agar to the pulvinar end

Time for abscission (hr.)					
(*a*)			(*b*)		
Control	Diffusate from young pulvini	Diffusate from abscinded pulvini	Control	Pulvini from attached leaves	Pulvini from abscinded leaves
Expt. 1			Expt. 3	55 (from senescent leaves)	
107	105	88	>120		45
Expt. 2			Expt. 4	56 (from young leaves)	
61	55	53	57		37

block is then applied to the cut surface of a 1-cm. section cut from the petiole of a primary leaf of a bean plant. The sections, or 'explants', include the distal pulvinus, the abscission zone and part of the petiole. They are aligned on 'Perspex' racks mounted over 3 per cent agar in Petri dishes maintained at 24° C. Every few hours, the pulvinar end of the explant is given a light tap to determine if separation of the abscission zone has taken place. Twenty explants are used per treatment.

As the primary leaves grow older, it is found that explants cut from their petioles take progressively longer to separate. With those from very young expanding leaves, abscission is complete after 25–35 hours; but when plants are growing vigorously in midsummer, explants from fully expanded primary leaves may fail to separate by the end of six days. Explants from leaves of all ages have been used in the present studies, and the results quoted have been selected to include a wide range of test material.

It will be seen from Table 1 (*a*) that when a block of agar containing the diffusate from the pulvinus of an abscinded bean leaf is applied to the pulvinar end of an explant, the average time required for abscission is shorter than for the control. Blocks containing the diffusate from the pulvini of young expanding leaves produce no significant effect. From these and other experiments, it can be concluded that as the leaves become senescent and approach abscission the diffusate is progressively more effective in accelerating abscission. Confirmation of the increase in the power to induce abscission with age of leaf is obtained from further experiments in which sections of the pulvini are excised from leaves of different ages and sealed to the pulvinar end of explants by a 1-mm. disk of 2 per cent agar. The substance or substances present in the pulvini of senescent and abscinded leaves is found to diffuse across the agar seal and to accelerate abscission of the explant, see Table 1 (*b*). No comparable stimulation has been observed with pulvini from very young leaves.

When whole pulvini, or agar blocks containing the diffusate derived from them, are sealed to the petiolar or proximal end of the explants, instead of to the pulvinar end, acceleration of abscission is again obtained, indicating that, unlike indole-acetic acid, the diffusate is effective from whichever side it reaches the abscission zone.

Other experiments have shown that the production of this abscission factor is not confined to the lamina. Diffusates from the pulvini of abscinded explants cut from young leaves, and from petiolar stumps which are becoming senescent as a result of removal of the lamina, are both effective in accelerating abscission.

Experiments with many evergreen and deciduous species have demonstrated that during the period of autumnal leaf-fall substances inducing abscission are of widespread occurrence in the petioles of senescent leaves. Comparisons have been made of the diffusate from the petioles of yellow leaves which have just completed abscission and that from green leaves which are still attached to the branches. To do this, a section from the leaf base 0·5 cm. long is placed proximal side down upon an agar block in the manner already described, and after twenty-four hours at 24° C. the leaf-base is removed and the block applied to the pulvinar or petiolar end of a bean explant. The results obtained for a selected number of trees and shrubs are listed in Table 2, and it is clear that an acceleration of abscission has resulted from the application of the diffusate from abscinded leaves of each species. The diffusate from the green leaves of the deciduous species, which at this time of year are fast approaching senescence, also accelerates abscission; but generally to a lesser extent. In the evergreen species, privet and *Rhododendron*, leaves in their first year of growth do not normally undergo abscission, and it is noteworthy that the diffusate obtained from the petioles of such green leaves is not found to accelerate abscission. It is only the diffusate from senescent leaves in their second or third year of growth which appears to be active. Diffusates from the first-year leaves of several *Rhododendron* species are, in fact, found to delay rather than hasten abscission.

A preliminary study of the diffusible factor from senescent leaves has revealed that it has the property of counteracting the retardation in abscission which results from treatment with indole-acetic acid. This conclusion is based on the following type of result. A 0·002-ml. drop of distilled water or an aqueous solution of indole-acetic acid (sodium salt) at 20, 50 or 100 p.p.m. is applied to the freshly cut surface of the pulvinar end of an explant. When the drop is completely absorbed, a block of plain agar or agar containing the diffusate is sealed to the pulvinar end. The results of such an experiment using the diffusate from *Pyrus aria* are given in Table 3 (*a*), and it is seen that although indole-acetic acid alone delays abscission the effect is partly or wholly reversed by the addition of the diffusate.

In other experiments, a block of agar or a segment of pulvinus from an abscinded primary leaf is sealed

Table 2. Average time in hours for abscission of bean explants treated at the pulvinar end with agar blocks containing diffusates from the petioles of previously attached or abscinded leaves

Species		Control	Diffusate from attached green leaves	Diffusate from abscinded leaves
Ulmus glabra	Expt. 1	102	77	48
	,, 2	84	72	55
Aesculus hippocastanum	,, 1	76	62	65
	,, 2	68	49	49
Ligustrum ovalifolium		> 58*	>59†	44
Rhododendron sutchuense		67	>77‡	55

* Abscission had not occurred in 25 per cent of the explants when the experiment was terminated at 96 hr.

† Abscission had not occurred in 15 per cent of the explants when the experiment was terminated at 96 hr.

‡ Abscission had not occurred in 35 per cent of the explants when the experiment was terminated at 144 hr.

Table 3. The percentage of explants abscinded within 100 hr. after treatment at the pulvinar end with 0·002 ml. drops of water or indole-acetic acid at 20, 50 or 100 p.p.m., followed by: (*a*) blocks of plain agar or blocks containing the diffusate from the petioles of abscinded leaves of *Pyrus aria* sealed to the pulvinar end; (*b*) blocks of plain agar, or a segment of abscinded pulvinus of *Phaseolus vulgaris* sealed to the pulvinar end

Indole-acetic acid (p.p.m.)	Per cent abscission within 100 hr.			
	(*a*) Subsequent treatment with		(*b*) Subsequent treatment with	
	Block of plain agar	Block containing diffusate	Block of plain agar	Segment of abscinded pulvinus
0	15	80	100	Not done
20	5	100	40	85
50	0	41	10	45
100	0	0	0	40

to the pulvinar end of an explant previously treated with a drop of indole-acetic acid. Typical results are given in Table 3 (*b*), and again this demonstrates that the diffusate from senescent pulvini counteracts the effect of indole-acetic acid.

The possibility that the factor could be ethylene has not been overlooked; but since explants in the process of abscission do not accelerate the abscission of intact explants enclosed with them, it seems unlikely that the active substance or substances can be gaseous.

On the basis of the present results it is proposed that leaf abscission may be controlled not only by endogenous auxins but also by some substance or substances which are produced as the leaf matures, and which reach a maximum at senescence. The question whether this factor is itself active in inducing abscission or whether it functions indirectly by altering the level of the effective auxins in the abscission zone must await the results of further investigations.

I am indebted to Miss Patricia Humphrys for carrying out the experiments with privet and to Prof. G. E. Blackman for his encouragement and for suggesting and supplying the two types of leaves from several species of *Rhododendron*.

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AN ASSOCIATION BETWEEN THE *P* AND *Jay* SYSTEMS OF BLOOD GROUPS

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THE system of blood groups called *P* was discovered by Landsteiner and Levine[1] in 1927. One antibody, anti-*P*, and one red cell antigen, *P*, define the system. The antigen *P* is inherited as a dominant Mendelian character; no antibody, and therefore no antigen, corresponding to the hypothetical allelomorphic gene *p* has yet been found. The phenotype *P*−, assumed to represent the genotype *pp*, has a frequency of 21·15 per cent in Europeans[2]. Traces of anti-*P*, active only at temperatures around 4° C., can be found in the serum of most *P*− persons[3]. However, human sera containing anti-*P* strong enough for diagnostic purposes are a rarity. Marked variation in the strength of the *P* antigen in different samples of blood was noted by the discoverers[1]: the variation has been proved to be due, at least in part, to the homozygous or heterozygous state of the donor[3].

The *Jay* system of blood groups was discovered by Levine, Bobbitt, Waller and Kuhmichel[4] in 1951. One antibody, anti-Tj^a, and one antigen, Tj^a, define the system. The antigen Tj^a is inherited as a dominant Mendelian character; no antibody, and therefore no antigen, corresponding to the hypothetical allelomorphic gene Tj^b has yet been found. The phenotype $Tj(a-)$, assumed to represent the genotype Tj^bTj^b, is a great rarity: fourteen $Tj(a-)$ persons, members of eight families, have been found[4–11]. The agglutinin anti-Tj^a is present in the serum of each of these people; most of the examples are also capable of hæmolysing $Tj(a+)$ red cells in the presence of complement. The frequency of the phenotype $Tj(a-)$ is not known: the propositi were brought to notice because of the antibody in their serum, but no random $Tj(a-)$ has been found though more than ten thousand white people have been tested[4–7,11].

Samples of blood from three unrelated $Tj(a-)$ people, Herr K.[11], Mrs. El.[9] and Miss Pa.[7], have recently been tested in this Unit and all three were *P*−. This was startling, for only one white person in five is *P*−. Reference to published work then showed that the *P* groups of three other unrelated $Tj(a-)$ persons and of one sib had been recorded, and all four were *P*−. The probability that six consecutive unrelated $Tj(a-)$ persons should be *P*− merely by chance is too remote to be entertained. The blood groups of all the known $Tj(a-)$ people are given in Table 1.

The antibody, anti-Tj^a, was then investigated, with the attention thus directed to the *P* system. Six anti-Tj^a sera were available (from Mrs. J.[4], Mrs. Mc.[5], Miss Pa.[7], Mrs. El.[9], Herr K.[11] and from a Swedish patient (Broman, B., personal communication)). Each serum after absorption with an equal volume of *P*− red cells gave the reactions of anti-*P*. Most of the resulting anti-*P* sera were much stronger, and reacted at higher temperatures, than the 'naturally occurring' anti-*P* found in the serum of normal *P*− donors.

Of one serum (Mrs. El.) there was plenty for more elaborate absorptions and elutions. All antibody

Table 1. The Blood Groups of *Tj*(*a*−) Persons

Country	Ref.	Propositi and *Tj*(*a*−) sibs	*ABO*	*MNSs*	*P*	*Rh*	*Lutheran Lu*^{a}	*Kell* K	*Kell* k	*Lewis* Le^a	*Lewis* Le^b	*Duffy* Fy^a	*Duffy* Fy^b	*Kidd* Jk^a	*Kidd* Jk^b
United States	4	Mrs. J.	*O*	*MN.S*	−	*CDe/CDe*	−		+	−		+			
		Her sister	*O*			*CDe/CDe*			+						
South Africa	5	Mrs. Mc.	*O*	*MsNs*		*cDE/cde*		+	+			+		+	
Poland	6	Frau Z.	*A*	*MN*	−	*CDe/cde*		−		−					
Australia	7	Mrs. Y.	*O*	*MSNs*		*cdE/cde*	−	−		−		−			
		Her sister (Miss Pa.)*	*O*	*MSNs*	−	*cde/cde*	−	−		−	+	+	+	+	+
United States	8	Mrs. E. E.	*O*	*MsNS*	−	*cDE/cde*		+	+	−		−			
		Her brother	*A*	*MsNS*	−	*CDe/cde*				−		+			
Canada	9	Mrs. El.*	*O*	*NsNs*	−	*cde/cde*	−	−		−	+	−	+	+	+
Japan	10	Rit Ho	*A*	*MN*		*CDe/CDe*									
		Her sister	*A*	*MsMs*		*CDe/CDe*		−		−		+		−	
		Her brother (Yoi)	*O*	*MsNs*		*CDe/CDe*		−		−		+		−	
		Her brother (Yas)	*O*	*MM*		*CDe/CDe*		−		−		+		−	
Germany	11	Herr K.*	A_2	*MSNs*	−	*cde/cde*	−	−	+	−	−	+	−	−	+

* The blood of the three people marked with asterisks was tested in this Unit. Miss Pa. is now in England; her *P* and *Kidd* groups have not previously been published. Mrs. El. is now in England; her groups have not previously been published.
Miss Pa. secretes *H* and Le^a but not *A* or *B*; Mrs. El. secretes *H* and Le^a but not *A* or *B*; Herr K. secretes *A* and *H* but not *B* or Le^a

could be removed by absorption with $P+$ red cells, and the ease of the removal was proportional to the strength of the *P* antigen of the absorbing cells. Eluates from the absorbing cells, whether $P+$ or $P-$, reacted more strongly with $P+$ than with $P-$ cells.

But the best evidence of the direct relationship of anti-Tj^a to the *P* system was provided when the serum of Mrs. El. was found, after titration, to give lytic and agglutination reactions which were strongest with strong $P+$ red cells, a little less strong with weak $P+$ cells and a little less strong still with $P-$ cells.

A close relationship between the *P* and *Jay* systems is therefore established. Though the nature of the relationship is not yet known, it is simplest to suppose that *Jay* is part of the *P* system. The facts would fit surprisingly well if the *P* system were constructed on the A_1A_2O pattern. To fit this pattern, the gene *P* has to become P_1, the gene *p* has to become P_2 and the gene Tj^b has to become *p*. Anti-*P* becomes anti-P_1 (like α_1 in the serum of an A_2 person) and anti-Tj^a becomes anti-P + anti-P_1 (like $\alpha + \alpha_1$ in the serum of a group *O* person). Absorption and elution tests using anti-Tj^a and $P+$ and $P-$ red cells give results directly comparable with the same tests using $\alpha + \alpha_1$ and A_1 and A_2 cells. There are doubtless other possibilities: Tj^b might, for example, represent suppression of *P* or *p*, but the A_1A_2O model offers an easy way of understanding the relationship of the *Jay* blood groups to the *P* system.

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ENZYMIC SYNTHESIS OF A 'BRANCHED' TRISACCHARIDE

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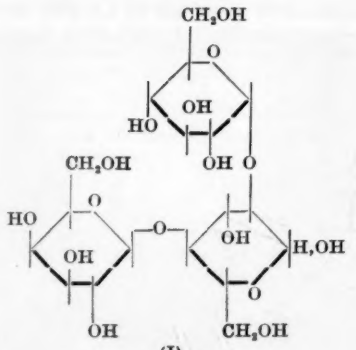
Evidence is now accumulating that oligosaccharides, rather than higher polymeric materials, are formed when dextransucrase acts on sucrose in the presence of relatively large amounts of certain simple sugars, which serve as chain-initiators (cf. refs. 1–3). In large-scale preparations of such oligosaccharides, it is often more convenient not to use a purified enzyme but instead to grow a dextransucrase-producing organism on a culture medium containing a high concentration of the chain-initiator in addition to the sucrose substrate[2]. For example, it was shown recently[2] that oligosaccharides (probably in the tri- and tetra-saccharide range) are produced when cultures of *Betacoccus arabinosaceous* (Birmingham strain) are grown on a medium containing yeast extract, inorganic salts, sucrose (2 per cent) and lactose (10 per cent). We now report the isolation, using the charcoal column technique[4], of a trisaccharide from such a culture, and describe the elucidation of its structure. This trisaccharide was chosen for investigation because it seemed from other studies (unpublished results obtained by us) that the αβ-D-glucose unit of the lactose was more likely to be the acceptor of the enzymically transferred glucose residue than was the β-D-galactose unit, in spite of the fact that the former constituted the reducing moiety. Such a transfer resulting in a novel trisaccharide synthesis was indeed found to occur, for the trisaccharide was shown to be O-β-D-galactopyranosyl-(1→4)-O-[α-D-glucopyranosyl-(1→2)]-D-glucopyranose (I).

Hydrolysis of the trisaccharide with 1·5 *N* sulphuric acid at 100° for 4 hr. gave a 96 per cent conversion (determined by cuprimetric titration) into glucose



(I)

and galactose; visual comparisons on paper chromatograms indicated that the glucose/galactose ratio was approximately 2/1. Partial hydrolysis with 1·1 *N* sulphuric acid at 90° for 1 hr. gave products with the R_F values of galactose, glucose and lactose, together with a component (*X*) which was very similar to sophorose (2-O-β-D-glucopyranosyl-D-glucose) in its R_F value and in the characteristic yellow-brown stain which it gave with an aniline hydrogen phthalate spray. Since it is the position, rather than the configuration, of the glycosidic linkage which governs the mobility of a disaccharide[6], this component could equally well have been 2-O-α-D-glucopyranosyl-D-glucose. While the reducing power of the trisaccharide towards alkaline hypoiodite[4] was 104 per cent of the theoretical value, that towards the Shaffer–Hartmann copper reagent[7] was only 0·3 per cent of the reducing power of glucose; such a discrepancy between the results of the two methods is shown by 2-O-substituted glucoses (for example, the corresponding values for 2 : 3-di-O-methyl-D-glucose were 100 and 14 per cent, respectively) (cf. refs. 6 and 8).

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Several important points of interest arise from this work, which has revealed a method for the enzymic synthesis of the rare α-1 : 2-glucosidic linkage. (Recently, Peat, Whelan and Hinson[10] detected the α-1 : 2-linked glucose disaccharide in a mixture of ten disaccharides formed from a glucose solution by an extract of *Aspergillus niger NRRL* 330.) We believe this to be the first enzymic synthesis *in vitro* of a 'branched' trisaccharide. The mechanism of its formation could be a general one for branched oligosaccharides; it involves the use of a carbohydrate primer in which a sugar residue, other than the usual non-reducing end unit, has the correct structure for it to serve as an acceptor of a transferred sugar residue. Moreover, there is an indication of a possible route to the synthesis of branched polysaccharides which does not involve branching of a linear polymer as is the case with glycogen and amylopectin (cf. ref. 11); thus, a 'branched' trisaccharide in the form of a glycoside (for example, phosphate, fructosyl derivative) could well serve as a substrate for a transglycosylase which transfers the three sugar units *en bloc* to a growing chain of a branched polysaccharide. This work also raises the possibility that the non-terminal glucose units in an α-1 : 6-linked glucose polymer might serve as primers for the enzyme system studied above, giving rise to dextrans with a few α-1 : 2-branch points in addition to the α-1 : 3- and α-1 : 4-branches commonly found.

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Table 1. The Blood Groups of *Tj(a−)* Persons

Country	Ref.	Propositi and *Tj(a−)* sibs	*ABO*	*MNSs*	*P*	*Rh*	*Lutheran Lu*^{a}	*Kell* K	*Kell* k	*Lewis* Le^aLe^b	*Duffy* Fy^aFy^b	*Kidd* Jk^aJk^b
United States	4	Mrs. J.	*O*	*MN.S*	−	*CDe/CDe*	−		+	−	+	
		Her sister	*O*			*CDe/CDe*			+			
South Africa	5	Mrs. Mc.	*O*	*MsNs*		*cDE/cde*		+	+		+	+
Poland	6	Frau Z.	*A*	*MN*	−	*CDe/cde*		−		−		
Australia	7	Mrs. Y.	*O*	*MSNs*		*cdE/cde*	−	−		−	−	
		Her sister (Miss Pa.)*	*O*	*MSNs*	−	*cde/cde*	−	−		− +	+ +	+ +
United States	8	Mrs. E. E.	*O*	*MsNS*	−	*cDE/cde*		+	+	−	−	
		Her brother	*A*	*MsNS*	−	*CDe/cde*				−	+	
Canada	9	Mrs. El.*	*O*	*NsNs*	−	*cde/cde*	−	−		− +	− +	+ +
Japan	10	Rit Ho	*A*	*MN*		*CDe/CDe*						
		Her sister	*A*	*MsMs*		*CDe/CDe*		−		−	+	−
		Her brother (Yoi)	*O*	*MsNs*		*CDe/CDe*		−		−	+	−
		Her brother (Yas)	*O*	*MM*		*CDe/CDe*		−		−	+	−
Germany	11	Herr K.*	A_2	*MSNs*	−	*cde/cde*	−	−	+	− −	+ −	− +

* The blood of the three people marked with asterisks was tested in this Unit. Miss Pa. is now in England; her *P* and *Kidd* groups have not previously been published. Mrs. El. is now in England; her groups have not previously been published.
Miss Pa. secretes *H* and Le^a but not *A* or *B*; Mrs. El. secretes *H* and Le^a but not *A* or *B*; Herr K. secretes *A* and *H* but not *B* or Le^a

could be removed by absorption with $P+$ red cells, and the ease of the removal was proportional to the strength of the *P* antigen of the absorbing cells. Eluates from the absorbing cells, whether $P+$ or $P-$, reacted more strongly with $P+$ than with $P-$ cells.

But the best evidence of the direct relationship of anti-Tj^a to the *P* system was provided when the serum of Mrs. El. was found, after titration, to give lytic and agglutination reactions which were strongest with strong $P+$ red cells, a little less strong with weak $P+$ cells and a little less strong still with $P-$ cells.

A close relationship between the *P* and *Jay* systems is therefore established. Though the nature of the relationship is not yet known, it is simplest to suppose that *Jay* is part of the *P* system. The facts would fit surprisingly well if the *P* system were constructed on the A_1A_2O pattern. To fit this pattern, the gene *P* has to become P_1, the gene *p* has to become P_2 and the gene Tj^b has to become *p*. Anti-*P* becomes anti-P_1 (like α_1 in the serum of an A_2 person) and anti-Tj^a becomes anti-P + anti-P_1 (like $\alpha + \alpha_1$ in the serum of a group *O* person). Absorption and elution tests using anti-Tj^a and $P+$ and $P-$ red cells give results directly comparable with the same tests using $\alpha + \alpha_1$ and A_1 and A_2 cells. There are doubtless other possibilities: Tj^b might, for example, represent suppression of *P* or *p*, but the A_1A_2O model offers an easy way of understanding the relationship of the *Jay* blood groups to the *P* system.

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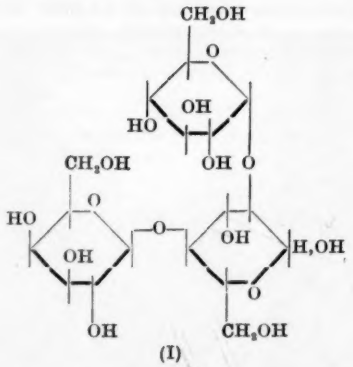
ENZYMIC SYNTHESIS OF A 'BRANCHED' TRISACCHARIDE

By Dr. R. W. Bailey, Dr. S. A. Barker, Dr. E. J. Bourne and Prof. M. Stacey, F.R.S.
Chemistry Department, The University, Birmingham 15

Evidence is now accumulating that oligosaccharides, rather than higher polymeric materials, are formed when dextransucrase acts on sucrose in the presence of relatively large amounts of certain simple sugars, which serve as chain-initiators (cf. refs. 1–3). In large-scale preparations of such oligosaccharides, it is often more convenient not to use a purified enzyme but instead to grow a dextransucrase-producing organism on a culture medium containing a high concentration of the chain-initiator in addition to the sucrose substrate[2]. For example, it was shown recently[2] that oligosaccharides (probably in the tri- and tetra-saccharide range) are produced when cultures of *Betacoccus arabinosaceous* (Birmingham strain) are grown on a medium containing yeast extract, inorganic salts, sucrose (2 per cent) and lactose (10 per cent). We now report the isolation, using the charcoal column technique[4], of a trisaccharide from such a culture, and describe the elucidation of its structure. This trisaccharide was chosen for investigation because it seemed from other studies (unpublished results obtained by us) that the αβ-D-glucose unit of the lactose was more likely to be the acceptor of the enzymically transferred glucose residue than was the β-D-galactose unit, in spite of the fact that the former constituted the reducing moiety. Such a transfer resulting in a novel trisaccharide synthesis was indeed found to occur, for the trisaccharide was shown to be O-β-D-galactopyranosyl-(1→4)-O-[α-D-glucopyranosyl-(1→2)]-D-glucopyranose (I).

Hydrolysis of the trisaccharide with 1·5 *N* sulphuric acid at 100° for 4 hr. gave a 96 per cent conversion (determined by cuprimetric titration) into glucose



(I)

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Interference Photography of the Chromospheric Spectrum

The high resolution and dispersion available with interference spectroscopes such as the Fabry–Pérot interferometer has led to the development of standard techniques for their employment in the study of the Fraunhofer absorption spectrum[1]. Until very recently, no such success had attended efforts to observe interferometrically the emission spectrum of the solar corona and the chromospheric flash spectrum. Although the flash spectrum is much stronger than that of the corona, its interferometric observation is complicated by the fact that it is confined to an extremely narrow layer, which extends only some 10″ beyond the much brighter solar limb.

During the total solar eclipse of June 30, 1954, Jarrett and von Klüber succeeded[2] in obtaining measurable fringes in the green coronal line at 5303 A. An attempt by Brück and Jackson to photograph the chromospheric spectrum interferometrically during the total solar eclipse of February 25, 1952, failed to produce fringes, but the authors were able to conclude from their observations that the unblended lines included in their investigation[3] must have widths in excess of 1·2 cm.$^{-1}$, or 0·24 A. at 4471 A.

The stronger lines of the chromospheric spectrum can be observed in the uneclipsed sun by setting the slit of the spectroscope across or tangentially to the solar limb, so that it intersects the chromosphere. When observed by this method the chromospheric emission lines have superimposed upon them a Fraunhofer absorption spectrum produced by atmospheric and instrumental scatter from the sun's limb. Satisfactory observations of this kind can therefore only be made when a combination of suitable atmospheric conditions occurs.

During the summer of this year, the problem of photographing the interferometrically observed spectrum of the chromosphere of the uneclipsed sun has been investigated at the University Observatory, Oxford, and a series of satisfactory plates obtained. These show conspicuous fringe systems of the emission lines H_α (6563 A.), D_3 (5876 A.), H_β (4861 A.), and of the H and K lines (3968, 3934 A.).

The instrument used for this work has been the new Oxford 35-metre solar tower, in which a 20-in. diameter paraboloid of fused quartz provides a solar image about 32 cm. in diameter. The image was formed on a screen containing a slot which selected a small region of the solar limb. The region so selected was re-imaged on the slit of a Hilger medium glass spectrograph, by means of a system comprising a field lens, collimator and camera each of 50 cm. focal length. The spectroscopic dispersion was about 40 A./mm. at 5876 A. The slit width was 0·02 mm. The solar limb was adjusted to be tangential to the slit, the point of contact coinciding with the base of the slit. Under these conditions, the full height of the slit, about 2 cm., corresponds to a height of 8″ (5,800 km.) above the solar limb. A Fabry–Pérot interferometer with a 1-mm. invar spacer was placed in the parallel beam between the auxiliary collimator and camera, and tilted so that several diametral sections from one side of the ring pattern would fall within the chromospheric region. The measured mean values of the reflectivity and transmission of the newly deposited silver coatings were 95·5 and 2·5 per cent at 5500 A., giving a theoretical resolving power of 260,000. Exposure times varied from 1 to 2 min., and during the exposure the solar limb was guided by means of an optical control.

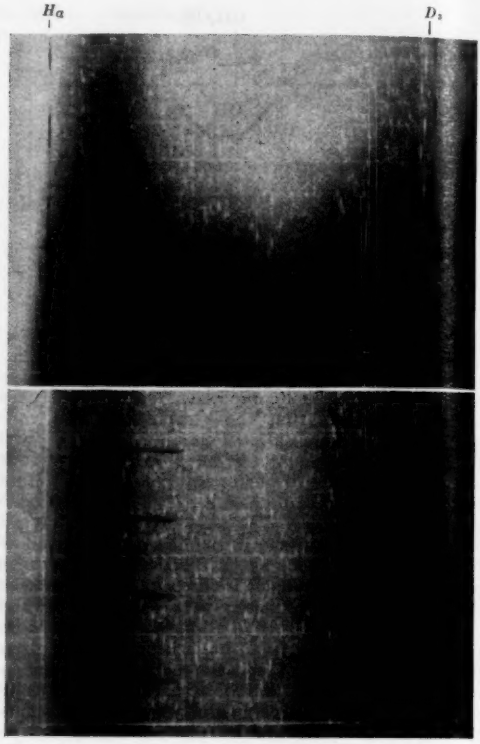

Fig. 1. Interference spectra of the Sun (negative prints) λλ 5700–6600 A. (*a*) Chromospheric H_α and D_3, and limb scatter spectrum from 500 to 5,500 km. above the solar limb. (*b*) Photospheric spectrum at solar centre with superimposed fringes of cadmium 6438 A.

In addition to a pair of chromospheric spectra, the plates have a photometric calibration exposure and an interference spectrum of the solar centre, on which is superimposed a control set of fringes obtained by replacing the solar image by a cadmium discharge lamp and widening the slit. These features can be seen in Fig. 1, which is an enlargement of part of a typical plate. The Fraunhofer scatter spectrum in (*a*) and the centre spectrum (*b*) both show the well-known knotted appearance in the absorption lines. On the original plates, the very fine parabolic channels can be traced nearly to H_α, where they become submerged in plate grain. In (*a*), fringes of the chromospheric helium line 5876 A. are seen in emission. The range between successive orders at this wave-length is 1·73 A., and from this the great width of the line is apparent. The control fringes of cadmium in (*b*) indicate that the actual resolving power is adequate to provide reliable profiles of this line. The fringe system of H_α, which appears prominently on all plates, is more complicated and variable. In general, it appears to be wider than the range of the étalon

(2·1 A. at 6563 A.) in the lower chromosphere, but higher up it gives fringes which show self-reversal. In the corresponding centre spectrum (*b*) the absorption line of H_α is also too broad to show fringes, and D_3 is absent.

A fuller account of this work and of the profiles of the D_3 line in the latitude range covered will be communicated elsewhere.

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Oxford.
Sept. 24.

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Palæomagnetic Study of Rocks from the Grand Canyon of the Colorado River

Dr. S. K. Runcorn has recently described measurements of remanent magnetization made on sediments collected from the Colorado Plateau of Arizona[1] and has compared these results with those made on rocks of similar age from Great Britain. During the summer of 1954 I also collected from the Grand Canyon of the Colorado River for the purpose of making studies of remanent magnetism on these rocks. I wish here to compare my results with those obtained by Dr. Runcorn.

Of the many rocks exposed in the Grand Canyon, only those of the Supai Formation (Permian Age) and the Hakatai Shale (Algonkian Age) could be shown to have retained, up to the present, the magnetization they obtained on deposition. A comparison of the results obtained by Dr. Runcorn and myself is given in Table 1.

Table 1

Authority	Formation	Magnetic declination	Magnetic inclination	Rad. of 95% probability	Deduced pole position
Runcorn	Supai	S. 47·3° E.	+ 22·9°	7·5°	121° E., 26° N.
Doell	Supai	S. 34° E.	+ 8°	7°	115° E., 39° N.
Runcorn	Hakatai*	S. 87·7° W.	+ 72·8°	5·4°	150° W., 31° N.
Doell	Hakatai*	S. 66° W.	+ 72°	17·5°	144° W., 18° N.

* The magnetic directions are not corrected for geological dip (about 10°).

The angular difference between the average directions is 19° for the Supai rocks and 7° for the Hakatai rocks. It is very probable that Runcorn's direction for the Supai should be farther to the south with a smaller inclination[2], thus bringing the angular difference between the two sets of measurements within the probable error.

It is important to note that these measurements were made entirely independently. Runcorn restricted his collection to the Kaibab Trail, whereas my collections were taken equally from the Kaibab and Bright Angel Trails (separated by about 2½ miles). Further, Dr. Runcorn's measurements were made on an astatic type instrument, whereas mine were made on a 'rock generator' type magnetometer made available by the Stanolind Oil and Gas Co., Tulsa, Oklahoma. The comparison is very encouraging, in that the number of samples measured in each determination is of the order of ten to twenty.

No 'reversals' were found by Dr. Runcorn or me in either the Supai rocks or the Hakatai rocks. Thus, if the main geomagnetic field reverses itself, as postulated by Hospers for the Tertiary[4], and by Clegg *et al.* for the Triassic[5], such reversals are not evident in the periods represented by the Supai and Hakatai rocks.

Details of this work will appear elsewhere after further studies of magnetic stability have been made.

I am indebted to the Institute of Geophysics, University of California, for a grant to cover expenses. This work forms a portion of a dissertation submitted to the University of California in partial satisfaction of the requirements of the degree of Ph.D.

Richard R. Doell

Department of Physics,
University of Toronto.

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Anisotropy of Effective Gas Diffusion Coefficients in Extruded Carbon Rods

It is well known that, in extruded cylindrical samples composed of either particles of amorphous carbon or graphitized carbon, the properties of thermal expansion, thermal conductivity and electrical conductivity are highly anisotropic[1]. The anisotropy in these properties is caused by the orientation of the irregular particles with their long side parallel to the direction of extrusion and by the inherent anisotropic behaviour of the crystallites composing the particles.

The orientation of irregular particles would also be expected to produce anisotropy of effective gas diffusion coefficients in extruded carbon rods. To investigate this phenomenon, effective diffusion coefficients, D_{eff} (H_2–N_2), were determined on three commercial samples, all using coal-tar pitch as a binder: a lampblack gas baked at about 1,000° C. (*A*), a petroleum coke graphitized at about 2,500° C. (*B*), and a petroleum coke graphitized at about 3,000° C. (*C*). The apparatus and procedure described by Weisz and Prater[2] and us[3] were used. Samples ⅛ in. long by ¼ in. in diameter were used; they were previously cut either parallel or perpendicular to the direction of extrusion from rods 2 in. long by ½ in. in diameter. The results on each sample, shown in Table 1, represent at least three different specimens, with the individual values duplicated within ± 5 per cent.

D_{eff} (H_2–N_2) was calculated on the basis of the external geometrical length of the cylinder. If the pores in the solid are completely random in direction, the average length of travel of gas is shown by Wheeler[4] to be 1·41 times the external length of sample (tortuosity factor). However, if the particles composing the sample are oriented by extrusion, it is

Table 1. Effective Diffusion Coefficients of Hydrogen–Nitrogen in Carbon Rods parallel and perpendicular to Direction of Rod Extrusion

Sample	D_{eff} (cm.²/sec., S.T.P.)		Ratio of D_{eff}
A	0·049	0·038	1·29
B	0·044	0·039	1·13
C	0·088	0·053	1·66

seen that the assumption of randomness of pore direction is no longer valid. Parallel to the extrusion direction the tortuosity factor would be expected to approach more closely to 1 (perfect channelling), the higher the degree of orientation. Conversely, the tortuosity factor perpendicular to the direction of extrusion would be expected to become progressively greater than 1·41 with increased orientation of the particles. Therefore, it is felt that the anisotropy of effective gas diffusion coefficients in the extruded carbon rods is primarily a result of differences in the tortuosity factor produced by particle orientation.

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A Comparative Study of the Mode of Action of X-Rays and Alkylating Agents

Pharmacological and toxicological researches have shown that the effects of nitrogen mustard are strikingly similar to those of ionizing radiation[1]. On account of the great similarity shown by the effects of mustards to irradiation effect, the mustards have been termed 'radiomimetic poisons'[2]. The similarity, furthermore, was found also in the action on the viscosity of deoxyribonucleic acid[3]. On the other hand, Auerbach[4] found that the types of genetic change induced by mustard gas are in some respects different from those caused by X-rays, and suggested that the mode of action of the two agents is also different. Widner *et al.*[5] and Koller *et al.*[6] compared the cytological effects in normal and tumour cells, and found a significant difference which they attributed to the difference in the mode of action of these agents. The mechanism of the effect, however, seems to involve many obscure points and demands further investigation from various points of view.

I have succeeded in establishing resistant variants of the Yoshida ascites tumour to methyl-*bis*-(β-chlorethyl)-amine N-oxide, one of the alkylating agents, by passing tumour cells through animals treated with the agents (MBAO-resistant subline)[7]. These resistant variants were proved to be cross-resistant to the other three alkylating agents, namely, methyl-*bis*-(β-chlorethyl)-amine and tris-(β-chlorethyl)-amine and tris-ethylen-imino-s-triazine, but not cross-resistant to the unrelated agents, namely, 8-azaguanine and colchicine[8]. It seemed, therefore, to be interesting to test whether the MBAO-resistant subline is cross-resistant to X-rays or not. The susceptibility to X-rays of tumour cells in the MBAO-resistant sublines was compared with that in the original sensitive strain of the Yoshida ascites tumour.

Rats of mixed breed and weighing about 100 gm. were used, each receiving an intraperitoneal inoculation of 0·02 c.c. of tumour ascites, containing about 2×10^6 tumour cells. Half the animals in each group (1,000 r. irradiation group, 200 r. irradiation group and non-irradiated control group) were inoculated with tumour cells of the resistant subline, and the other half were inoculated with those of the sensitive strain. They showed 100 per cent susceptibility to the tumour. The MBAO-s.c. resistant subline[7,8] was used as a resistant subline. A group of ten rats was exposed to a single dose of 1,000 r. whole-body X-radiation, and another group of sixteen rats to 200 r., on the fifth day after inoculation with the tumour. The radiation factors were: 160 kVp., 3 m.amp., half-value layer 1·02 mm. copper; filter, 0·5 mm. copper plus 1·0 mm. aluminium; focal skin distance, 30 cm.; and dosage rate 20 r./min. Besides these X-radiation groups, another ten rats served as control material without X-radiation. The sensitivity of the tumour cells to X-rays was judged by changes in the mitotic index (mitoses/2,000 tumour cells), which was calculated with Giemsa-stained smear preparations of the tumour ascites withdrawn just before exposure to X-rays, and 1, 3, 6, 9, 12, 24 and 48 hr. after the end of exposure. The mitotic index of non-irradiated control animals was calculated in the same way as in the irradiated animals. The mean values of the mitotic index in each group are represented in Fig. 1. All results were analysed statistically using the method of analysis of variance. On the variation of mitotic index of non-irradiated control group, a significant difference was not found between the MBAO-resistant subline and the original sensitive strain ($P > 0{\cdot}05$). Following exposure to X-radiation, as shown in Fig. 1, the mitotic cells in both resistant and sensitive strain decreased markedly

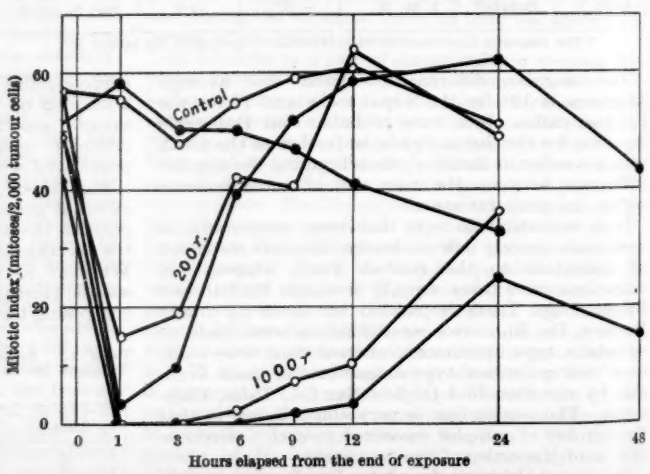

Fig. 1. Changes in the mitotic index following X-radiation
○—○, Original sensitive strain; ●—●, MBAO-resistant subline

in number. In the group exposed to 1,000 r. X-radiation the mitotic index recovered almost to the rate it was before exposure about 24 hr. after the irradiation, and after 200 r. irradiation it recovered in the same way about 9 hr. after the irradiation. In these irradiation experiments, the mitotic index of the resistant subline was always markedly less than that of the sensitive strain, which was thus still under the effect of irradiation. The difference between these two lines was not significant statistically ($P > 0.05$) in animals given 1,000 r., but it was significant ($P < 0.01$) in animals given 200 r. In other words, a significant difference on the sensitivity to X-rays was not found after 1,000 r. irradiation, but after 200 r. irradiation the MBAO-resistant subline was found to be more sensitive to X-rays than the MBAO-sensitive strain. The fact that there was no significant difference of sensitivity after 1,000 r. irradiation between the two lines may be attributed to the striking effects of X-rays at that dosage-level.

Hence the tumour cells resistant to methyl-*bis*-(β-chlorethyl)-amine N-oxide were not cross-resistant to X-rays. Further, from these results it can be inferred that alkylating agents and X-rays are different in their mode of action on the cell.

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Nature of Calcium Sulphate Gels in Ethylene Glycol

GILLE[1] has described the formation of a thick gel by saturating ethylene glycol with gypsum, $CaSO_4.2H_2O$, at 19° C., filtering carefully, and heating the solution to 40° C., at which temperature, owing to its decreased solubility, the calcium sulphate precipitates, but in the form of a gel. Gypsum has a structure[2] in which layers of water molecules alternate with $CaSO_4$ layers, and Gille suggests that the last-mentioned layers are preserved in the gel, but with ethylene glycol substituted for the water, and causing an indefinite expansion.

Such an expansion would be similar to that of montmorillonite, and we might expect it to be associated with a phenomenon of the same nature as 'interlamellar sorption' in that mineral[3].

These observations of Gille seemed of interest to us, in connexion with our studies on interlamellar swelling and sorption, and we decided to investigate Gille's gel by X-ray diffraction. We used the 'flat-layer' technique[4], which is convenient for this type of study, since a little of the moist gel can be spread on filter paper, which is then mounted directly on the specimen holder. Some ordinary powder photographs (specimen in glass tube) were also made.

Photographs of the gel show haloes, as given by liquids or amorphous substances. If then the filter paper containing the gel is washed with methanol, ethanol or acetone, to remove the excess of ethylene glycol, a line at 17 A. appears, which does not disappear on treating with other organic liquids; but if one drop of water is placed on the filter paper, the 7 A. line characteristic of gypsum appears. The line at 17 A. remains on treatment with a mixture of one part of water and two of methanol; but a mixture two parts of water and one of methanol, or one of water and two of acetone, causes the gypsum line to reappear.

Because of too rapid heating, and possibly of other causes not yet clarified, the calcium sulphate may fail to form a gel, and be precipitated instead as a light sediment of fine particles. These particles give a line at 17 A., similar to that given by the gel washed with organic solvents.

It seems, therefore, that ethylene glycol can be substituted for the water molecules between the gypsum layers, and that the resulting $CaSO_4 - C_2H_4(OH)_2$ complexes are stable in the presence of many organic solvents, but unstable in the presence of water, which readily expels the glycol molecules. So far as our experience goes at present, therefore, the reaction with ethylene glycol is rather specific.

We tried to carry out the same preparation with $CaHPO_4.2H_2O$, which is isomorphous with gypsum[5], but without success. The presence of hydrogen ions perhaps causes more powerful bonding between the layers than in gypsum.

A fuller account of this work will be given elsewhere.

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Action of Complexes of the Zinc Group Metals on the Tail Protein of Bacteriophage T_2r^+

A SPECIFIC reaction has been found between complexes of the zinc group metals and the bacterial virus, T_2r^+. Zinc ions ($M/100$) do not inactivate T_2r^+, but if a variety of metal-complexing agents are added to a solution containing zinc nitrate and T_2r^+, the virus is rapidly and irreversibly inactivated. Identical reactions occur with cadmium ions. Mercuric mercury inactivates T_2 as the free ion as well as when present as a complex ion. Cyanide complexes of all three metals and iodide complexes of cadmium and mercuric mercury inactivate the virus. Inactivation also occurs when a number of amino-acids (such as $M/100$ glycine or glutamic acid) and pure proteins (such as trypsin or chymotrypsin at 2 mgm./ml.) are used as metal-complexing agents. Versene complexes

of zinc, cadmium or mercuric mercury do not affect the virus.

The action of complexes of the zinc group metals is highly specific, since cyanide complexes of these metals inactivate only T_2r^+ and T_2r and do not inactivate T_1, T_4r^+, T_5, T_6r^+ and T_7, which invade the same host *E. coli* B. Further, cyanide complexes of other metals such as ferric and ferrous iron, silver, cobalt, nickel, and cuprous and cupric copper do not affect T_2.

Bacteriophage T_2r^+ has been shown by antigenic analysis to contain at least two proteins which are usually designated as head and tail proteins[1]. The viral deoxyribonucleic acid is located largely within the head of the virus particle. Electron micrographs of T_2r^+ inactivated by zinc or cadmium cyanide complexes show that the distal half of the virus tail is removed in the reaction (Fig. 1). The rate of viral inactivation is almost identical with the rate of appearance of virus particles with short tails (Fig. 2). T_2r^+ inactivated in this manner loses its ability to attach itself to host cells, to kill host cells or to reproduce. These changes in the biological properties of the virus, together with the results of the electron micrographs, indicate that the metal complex is acting upon the tail protein of the virus particle.

The head of the inactivated virus particles always appears intact, but it may or may not contain deoxyribonucleic acid, depending upon the experimental conditions. From *p*H 6·0 to *p*H 7·5 there is little or no release of viral deoxyribonucleic acid from the inactivated virus particle (measured as the release of phosphorus-32 from labelled virus particles). However, from *p*H 7·75 to *p*H 9·0, up to 95 per cent of the deoxyribonucleic acid is released into the suspending medium within five minutes.

From the known dissociation constants for the four cadmium cyanide complexes, it is possible to compare the rate of inactivation of T_2r^+ with the concentration of each complex. Using solutions of constant concentration of cadmium ions and varying concentration of cyanide ions, it was found that the inactivation-rate could be correlated only with the concentration of $Cd(CN)_3^-$. It appears that only $Cd(CN)_3^-$ inactivates T_2, whereas $Cd(CN)^+$, $Cd(CN)_2$ and $Cd(CN)_4^=$ do not affect T_2r^+. The rate of the viral inactivation, measured conveniently as $\frac{1}{\text{time for 60 per cent } T_2 \text{ survival}}$, increases logarithmically from *p*H 6·0 to *p*H 7·7, and does not increase further when the *p*H is raised to 8·7. When measured between 0° and 25° the Q_{10} for the inactivation reaction is 3·0. The fraction of T_2r^+ inactivated in a given time is independent of the initial virus concentration.

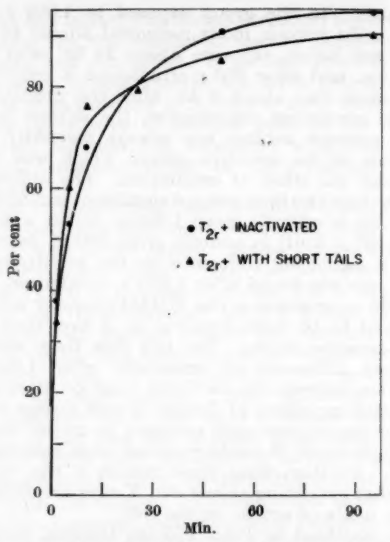

Fig. 2. The relationship between T_2r^+ inactivation by cyanide complexes of Cd^{++} and the appearance of viral particles with short tails. Samples were taken at various times from the reaction mixture (*p*H 7·0, 25·0°, 0·01 *M* $Cd(NO_3)_2$, 0·033 *M* NaCN, initial T_2 was 10^{11}/ml.) and assayed, and electron micrographs prepared in the usual manner. The fraction of virus particles with short tails was calculated from the electron micrographs

When *E. coli* B. is invaded by T_2r^+ bacteriophage the virus attaches itself tail first to the cell and afterwards the viral deoxyribonucleic acid is introduced into the cell. Any uninjected deoxyribonucleic acid, as well as the bulk of the viral protein which remains outside the cell, can be removed by stirring in a Waring blendor[2]. Recent experiments have demonstrated that T_2r^+ causes the release of nitrogenous materials from the bacterial cell wall, suggesting that the virus makes a hole in the cell wall[3].

It has been possible to show that after T_2 is adsorbed to the host cell and presumably has penetrated the cell wall, the release of viral deoxyribonucleic acid from its protein covering and its passage into the cell requires the presence of a polyvalent metal ion. When T_2r^+ labelled with phosphorus-32 is added to susceptible host cells in nutrient broth + *M*/40 versene (which complexes all polyvalent anions) the virus is adsorbed and the host cells are killed. However, none of the bacteria produces phage, and

Fig. 1. Effect of 0·01 *M* zinc nitrate plus 0·033 *M* sodium cyanide on T_2r^+ at *p*H 7·0 and 25°. After 1 hr. a sample was air-dried and shadowed with uranium. For comparison, the electron micrograph (× 8,000) shows a field containing one normal T_2 particle and one altered T_2 particle. The tail of the altered particle is one-half the normal length and is slightly thicker

by violent stirring of the cell-virus complex in a Waring blendor 90 per cent of the viral phosphorus-32 (that is, deoxyribonucleic acid) can be shaken off the host cell. In the absence of versene, only 30 per cent of the viral deoxyribonucleic acid can be removed from the host cell.

The similarity of the *in vitro* reaction between T_2 and metal complexes and the reactions occurring during invasion suggest that the mechanism by which the tail of the virus is altered and the deoxyribonucleic acid is liberated from its protein covering during virus-cell interaction involves the action of a metal complex.

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Direct Interaction between Copper Ions in the Molecules of Copper Acetate and Propionate

Examination of the magnetic properties[1] and also X-ray photographs[2] showed that the crystal of copper acetate consists of molecules, $Cu_2(CH_3COO)_4.2H_2O$, in which a direct type of metal-to-metal interaction might be anticipated. A similar metal-to-metal interaction was proposed for copper propionate[3]. Recently, we have made a quantitative determination of the dichroism of microcrystals of copper formate, acetate and propionate, demonstrating the existence of the copper-to-copper linkage in the crystal of the latter two compounds, and absence of this linkage in the former.

Polarized absorption spectra in the visible and near ultra-violet of copper acetate were determined by Tsuchida–Kobayashi's microscopic method[4]. Using the data of the crystal analysis[2], the components of the molecular absorption coefficients were estimated. The crystal shows in the above regions three absorption bands, at 43, 80 and 100×10^{13} c./s. For the band at 43×10^{13} c./s., which is usually supposed to be due mainly to the copper atom in combination with the ligands[5], absorption is much stronger with the electric vector along the plane containing four oxygen atoms around the copper atom than with the electric vector along the direction binding two copper atoms in a molecule. This relation agrees with the rule previously derived for the band of a similar kind with planar complexes of various metals[6]. The band at 80×10^{13} c./s. is of a new kind that has hitherto seldom been found, since most cupric complexes usually exhibit not more than one electronic absorption band of moderate intensity in the visible and near ultra-violet[5]. Thus the appearance of the new band at 80×10^{13} c./s. might be taken as an indication of the linkage between two copper atoms. The present measurement indicates that for this band the electric vector along the Cu–Cu axis is about 2·5 times as strongly absorbed as that perpendicular to this axis. This relation is different from the polarization characteristic for the absorption bands of typical planar complexes as well as for the 'copper band' at 43×10^{13} c./s. The reversal of the polarization property is in agreement with the assumption of the copper-to-copper linkage in $Cu_2(CH_3COO)_4.2H_2O$.

A similar measurement of dichroism was made with a crystal of copper propionate, $Cu(C_2H_5COO)_2.H_2O$. This exhibits a similar band of the new kind at 80×10^{13} c./s., in addition to a band at 43×10^{13} c./s., suggesting the existence of the copper-to-copper linkage. The polarization of the band at 80×10^{13} c./s. is found to be the reverse of that of the band at 43×10^{13} c./s. This relation, similar to that for copper acetate, also supports the above assumption.

The measurement shows that the crystal of copper formate tetrahydrate involving no copper-to-copper linkage[7] exhibits no band of the above kind at 80×10^{13} c./s. This also seems to support the metal-to-metal linkage in the crystals of copper acetate and propionate.

Copper acetate and propionate in alcohol or chloroform are found to show the band at 80×10^{13} c./s. It is concluded, therefore, that in the solution there should be such entities as $Cu_2(CH_3COO)_4X_2$ or $Cu_2(C_2H_5COO)_4X_2$ ($X = H_2O$, C_2H_5OH, or $CHCl_3$) in which the copper-to-copper linkage could exist.

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Chemiluminescence in the Decomposition of the Propyl Nitrates

The decomposition of the alkyl nitrates is chemically complex, and studies of the spontaneous ignition of methyl and ethyl nitrates have shown that this complexity is associated with a variety of visually distinct modes of inflammation. Thus methyl nitrate[1–3] may undergo three different modes of decomposition: (1) slow decomposition unaccompanied by light; (2) chemiluminescent decomposition; and (3) explosive ignition. Sharp limits of pressure and temperature separate these different modes. Similar behaviour has been found for ethyl nitrate[1,2].

The inflammation of *n*- and *sec*-propyl nitrates has now been examined, and the critical pressure limits above which chemiluminescence and explosion occur have been measured over the temperature-range 240–340° C. These limits in a quartz reaction vessel, volume 350 cm.^{3}, surface to volume ratio 1·0 cm.$^{-1}$, are shown in Fig. 1.

sec.-Propyl nitrate shows the same two modes of inflammation as methyl nitrate. For example, at 260° C. when a pressure of 0·4 mm. is admitted to the reaction vessel, reaction is accompanied by an immediate faint bluish-white luminescence lasting about half a second. Above a pressure of 7·5 mm., the luminescence is succeeded after a very short induction period by explosive ignition. At low temperatures the two different modes of reaction are sharply differentiated. As the temperature is raised, so the pressure limits come together and the distinction between luminescence and explosion becomes less marked.

n-Propyl nitrate does not show two distinguishable modes of inflammation. At temperatures above 280° C., when the critical pressure limit is exceeded, decomposition is accompanied by an immediate, faint, brief glow of white light. The critical pressure limit resembles the chemiluminescence limit of the other nitrates rather than their explosive limit.

The decompositions of all these alkyl nitrates thus resemble the oxidations of many hydrocarbons, which show cool and blue flames, in addition to slow reaction and explosion. The emitter in these hydrocarbon flames is well known to be excited formaldehyde, and it has been suggested[1] that it is also the source of the luminescence in the decomposition of nitrates. This suggestion is supported by recent spectroscopic work on the decomposition flames of methyl[5] and ethyl[6] nitrates, from which formaldehyde emission has been found.

In the oxidation of hydrocarbons the origin of the excited formaldehyde is not known. An energy of about 75–80 kcal. mole^{-1} is necessary; but it has been estimated[4] that fewer than ten excited formaldehyde molecules are involved for every million fuel molecules which react. It has been suggested[7] that the alkoxy radical $CH_3O\cdot$ is the precursor of CH_2O^*:

$$HO\cdot + CH_3O\cdot \rightarrow H_2O + CH_2O^* \quad \Delta H = -95 \text{ kcal.}$$

and recent data[8] on alkoxy radical thermochemistry show that this is energetically satisfactory. Other reactions between a methoxy radical and another radical may also be sufficiently exothermic.

In decomposition reactions of the type described here—of nitrates *R*ONO$_2$, nitrites *R*ONO, peroxides *ROOR'* and hydroperoxides *R*OOH—luminescence is always associated[9] with the presence of alkoxy radicals generated in the initial fission; for example,

$$C_3H_7ONO_2 \rightarrow C_3H_7O\cdot + NO_2$$

Further study of these alkoxy radicals, which are also known[10] to play an important part in hydrocarbon oxidation, may provide the key to the origin of cool flames.

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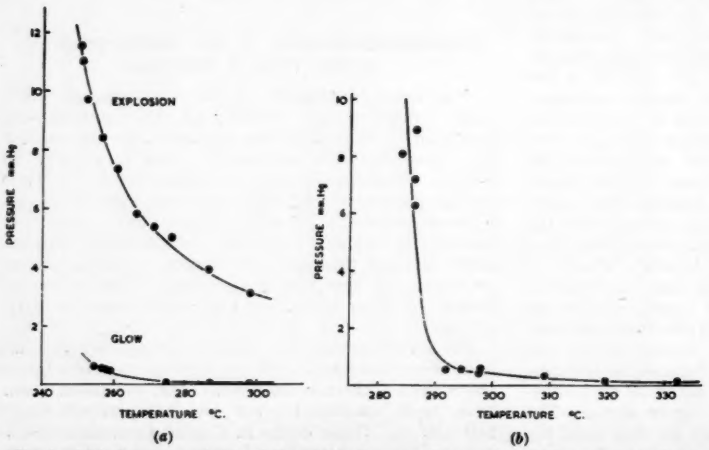

Fig. 1. Critical pressure limits of the visible decomposition modes of (*a*) *sec.*-propyl nitrate, and (*b*) *n*-propyl nitrate

Separation and Identification of Phenols by Paper Chromatography

The application of paper chromatography to the qualitative separation of phenols and phenolic derivatives has been reported by a number of workers[1]. The methods described employ the one-dimensional partition technique and they separate, with varying degrees of efficiency, phenolic derivatives having fairly pronounced structural differences.

Recent work in this laboratory[2] on the analysis of vitamin E has shown that a mixture of five tocopherols (differing only in methylation in the phenolic ring) can be separated completely by a two-dimensional technique. This technique consists of a first-dimensional separation by adsorption chromatography on zinc carbonate - impregnated paper, followed by second-dimensional reversed-phase partition chromatography on the same paper impregnated with liquid paraffin. The tocopherols, in this system, separate as would be expected from theoretical consideration of the methylation relative to the phenolic hydroxy-group. It was therefore of interest to see whether such a chromatographic system would be useful in separating closely related simple monohydric phenols.

A number of modifications to the system were made. Benzene was used as the developing solvent in the first dimension, since the lower phenols are not soluble enough in *cyclo*hexane. This, in turn, required a heavier deposition of zinc carbonate in the paper than had been used previously. In the second dimension, ethyl

Table 1. *R* AND R_F VALUES OF PHENOLS
R values are measured from leading edge of spot and R_F values to middle of spot

Substance	*R* value	R_F value
Phenol	0·27	0·74
o-Cresol	0·50	0·53
m-Cresol	0·30	0·60
p-Cresol	0·30	0·60
2-Ethyl-phenol	0·53	0·45
4-Ethyl-phenol	0·32	0·50
2-Propyl-phenol	0·55	0·35
3-Propyl-phenol	0·35	0·40
2,5-Xylenol	0·53	0·44
3,4-Xylenol	0·33	0·50
3,5-Xylenol	0·33	0·50
2-Methyl-6-propyl-phenol	0·78	0·20
3-Methyl-6-propyl-phenol	0·60	0·25
3-Methyl-6-isopropyl-phenol	0·60	0·18
2-Methyl-5-isopropyl-phenol	0·60	0·18
2-Ethyl-6-propyl-phenol	0·82	0·10

oleate was used as the stationary phase and the concentration of aqueous ethanol was changed.

Squares of Whatman No. 1 paper (25 cm. × 25 cm.) are immersed in a solution, prepared by suspending zinc carbonate (B.P.C. 40 gm.) and ammonium carbonate (30 gm.) in water (500 ml.) and adding 0·880 ammonia (200 ml.). The papers are hung in air for an hour, dried at 95° for three hours, and then ruled lightly in pencil, as shown in Fig. 1 ($AB = AE =$ 1 cm., $BC = 4$ cm.). The phenol or mixture of phenols (5–20 μgm. of each), dissolved in a suitable solvent, is applied to a prepared paper as a thin line along *FG*. The paper is then hung vertically in a tank from edge *HY*, with edge *AD* dipping in the solvent, and developed by the ascending method with dry benzene. The walls of the tank are lined with benzene - saturated filter paper. After three hours, the paper is removed and dried in air. The area *CDXY* is now immersed in a 5 per cent solution of ethyl oleate in light petroleum (40–60°), removed and allowed to dry. The solvent in the chamber is replaced by 40 per cent (v/v) aqueous ethanol and the paper hung in the tank with edge *AH* dipping in the solvent. The chromatogram is developed for sixteen hours, again by the ascending method. After drying, the paper is sprayed with any of the well-known phenol-spotting reagents, after which the individual phenols appear as a series of well-defined elliptical spots in the area *CDXY*.

Table 1 gives the *R* values in the first dimension and R_F values in the second dimension for a number of simple phenols. The results indicate a striking conformation between chromatographic behaviour and molecular structure. *R* and R_F values are both additive and constitutive functions, each being effected by contributions from carbon side-chains, according to the following rules. For each carbon atom in the side-chains, the *R* value is increased by 0·03 and the R_F value is decreased by 0·10; each substituent *ortho* to the hydroxy group further increases the *R* value by 0·20 and decreases the R_F value by 0·05. (Phenol itself has a slightly anomalous R_F value and, in the R_F series, *p*-cresol is better taken as the reference compound.) In the two examples given, simple branching in the side-chain seems to have an additional effect on the R_F value, decreasing it by a further 0·07, but has no effect on the *R* value.

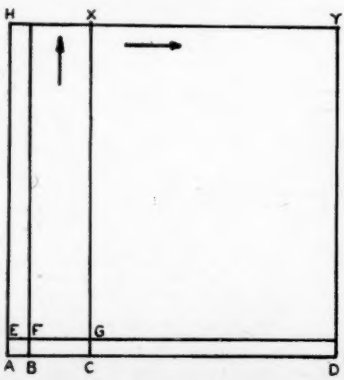

Fig. 1

From Table 1, it will be seen that many closely similar phenols are readily separated on the two-dimensional chromatogram, although others are not. In fact, the possibility of separation can be calculated.

The results are in general agreement with those already found on heavily substituted phenols such as the tocopherols[2], and it appears that the technique may have a more general usefulness in the isolation, separation and identification of phenol derivatives. With suitable modifications of the stationary and mobile phases, the method might be extended to more complex mono- and di-hydroxy derivatives, and it would be interesting to see whether the two-dimensional chromatographic behaviour of a highly complex phenol such as α-tocopherol could be completely correlated, through a series of chromatograms, with a simple substance such as, for example, *ortho*-cresol.

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Application of Paper Chromatography to Structural Problems in the Veratrum Alkaloid Group

IN a previous communication[1] we have described procedures for the separation, by paper chromatography, of the natural ester alkaloids derived from veracevine, cevagenine and cevine, as well as some partially synthetic esters of these alkamines. The most suitable solvent system proved to be chloroform on formamide-impregnated paper; detection was carried out with Dragendorff's reagent or by reaction with concentrated sulphuric acid.

A study of the effect of structure on the chromatographic behaviour of this group of compounds showed that the mobility is affected by the structure of the alkamine, the nature of the acid moiety, the number of ester groups and—very markedly—by the position of the esterified hydroxyl groups. In the case of the partially synthetic acyl derivatives, where the structure of the alkamine and the acylating agent are known, the remaining structural features to be

determined are the number and position of the esterified hydroxyl groups.

As a result of the non-equivalence of the hydroxyl groups of the veratrum alkamines, the R_M value of their derivatives is not a simple linear function of the number of free hydroxyl groups (cf., for example, ref. 2). Hence this relation cannot be used directly to determine the number of ester groupings; on the other hand, it becomes possible for the same reason to derive information as to the position of these esterified hydroxyl groups.

Since the hydroxyl groups in the veratrum alkamines form a number of diol groupings, we have attempted to exploit the reaction of such diol groupings with boric acid to determine the number of free glycol groups and hence in some cases the number and position of esterified hydroxyl groups. The same type of complex formation has previously been used, in the case of sugars[2–5], phenols and aromatic hydroxyacids[6], to decrease the rate of movement of suitably constituted compounds in paper chromatography.

In our procedure, the compound under examination is run in two parallel chromatograms with chloroform as the mobile phase on paper impregnated with formamide containing 5 per cent boric acid in one case, and with formamide alone in the other. Since the glycol–borate complexes are of a highly polar character, the rate of movement of compounds containing suitable glycol systems will be greatly decreased on the boric acid – impregnated paper. The difference in the R_M values for the same compound in the two parallel experiments (ΔR_M) will, moreover, give a direct indication of the number of free α-glycol systems present. Of the veratrum alkamines, veracevine and cevine contain three such systems (3 : 4, 12 : 14, and 16 : 17 or 17 : 20), cevagenine two (12 : 14, and 16 : 17 or 17 : 20). The examples recorded in Table 1 show that the presence of two glycol systems leads to ΔR_M values between 0·8 and 1·2 units, the presence of a single glycol grouping corresponds to a ΔR_M of 0·3–0·45, and in the absence of a free α-glycol system, the R_M values are the same in presence and in absence of boric acid.

The change in ΔR_M upon acylation, upon partial methanolysis of polyester derivatives, etc., gives an indication of the number of glycol systems blocked by esterification of one or both hydroxyl groups involved. Similarly, information as to the presence of an ortho-ester grouping and, in the case of cevagenine, as to its position (ring *C* or ring *D*) may be readily obtained. Further possibilities of application are evident.

Table 1

	Formamide		Formamide–boric acid		ΔR_M	No. of free glycol systems
	R_F	R_M	R_F	R_M		
3:4-Diacetylcevine	0·55	−0·08	0·09	1·0	1·08	2
3:16-Diacetylcevine	0·14	0·78	0·03	1·6	0·82	2
3:*X*-Diacetylcevine*	0·55	−0·08	0·30	0·37	0·45	1
3:4:16-Triacetylcevine	0·78	−0·57	0·20	0·62	1·19	2
3:4:*X*-Triacetylcevine	0·55	−0·08	0·30	0·37	0·45	1
3:4:16:*X*-Tetraacetylcevine	0·78	−0·57	0·64	−0·25	0·32	1
3:4:16-Triacetylcevine-D-orthoacetate†	0·62	−0·2	0·59	−0·17	0·03	0

* Chromatography and oxidation studies show that *X* is position 12 or 14.

† Developed with benzene–chloroform (7 : 3).

Table 2

	Group constant *G*		Position factor *a*
Acetyl	−0·7	*C*.3	2
α-Methylbutyryl	−1·2	*C*.16	1
Benzoyl	−1·2	*C*.4	2·15*
Veratroyl	−1·35	*C*.*X*	0*

* These values have so far only been verified for the acetyl derivatives.

The results obtained by the above method are of interest with regard to the configuration of the glycol system in position 17 : 20. This configuration has not yet been securely established[7], though Barton *et al.*[8] suggest that it is *trans*, on the grounds that 3 : 4 : 16-triacetylcevine is inert toward lead tetraacetate oxidation. On the other hand, however, our results indicate clearly (Table 1) that this glycol system is capable of complex formation with boric acid; past experience[9] would seem to suggest that it is therefore more likely to have the *cis* configuration.

On the basis of the experimental material accumulated in this work, we have attempted to calculate the group constants, *G*, for the various acyl groups used to esterify the veratrum alkamines. Martin[10] has shown that the introduction of a new group to a given fundamental molecule leads to a change in the partition coefficient (and hence in the R_F and R_M values) which is dependent on the nature of the group and the solvent system, but not on the nature of the fundamental molecule. As has been shown above, in the case under consideration it is further necessary to introduce factors expressing the effect of the position at which the change is made. Thus we may write:

$$\log\left(\frac{1}{R_F} - 1\right) = R_M = Z + a_x G_1 + a_y G_2 + \ldots$$

where Z is the fundamental constant (for cevine, $Z = 2{\cdot}9$), G_1, G_2 . . . are the group constants for the various acyl groupings, and a_x, a_y . . . are the position factors for the particular hydroxyl groups esterified. Some values for G and a are given in Table 2.

The use of this expression and the appropriate constants makes it possible to predict R_M and hence also R_F values for isomeric mono- and poly-esters of the veratrum alkamines. For the chromatographic detection and identification of esters of any further acid it is, moreover, sufficient to determine experimentally the R_F value of a single alkamine ester of this acid.

A detailed account of this work will be published elsewhere[11].

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Paper Chromatography of Steroid Glucuronosides and Sulphates

We wish to report the separation by paper chromatography of a number of steroid glucuronosides and sulphates. The composition of the three systems reported and the conjugates used are given in Table 1, together with the R_F values noted in a representative experiment. 10–50 gamma amounts of the free acids or their sodium salts in methanol were spotted on 22½-in. lengths of Whatman No. 1 paper and, after equilibration overnight at room temperature in paper-lined glass tanks, the mobile phase was added to the trough and descending chromatography was carried out for periods of 4–8 hr. Following chromatography, the papers were dried in a current of air at room temperature, and the conjugates were detected by spraying with, or dipping in, 2–4 per cent phosphomolybdic acid in absolute ethanol followed by heating at 90°–100° C. for 5 min. Conjugate 2 was also detected by dipping in 15 per cent aqueous phosphoric acid, followed by heating at 90° C. for 20 min. and examination under ultra-violet light[1], or by dipping in a triphenyltetrazolium chloride reagent prepared by combining immediately before use one volume of 2 per cent triphenyltetrazolium chloride in water with four volumes of 10 per cent sodium hydroxide in 60 per cent aqueous methanol.

In these experiments the ambient temperature varied from 23° to 33° C.; but in the course of a single experiment the temperature change usually did not exceed 3 degrees. Although R_F values varied slightly with temperature, it was possible to use these systems at temperatures as low as 4° C. and as high as 38° C.

System I has been used chiefly to separate conjugates 1 and 2 recovered from urine following the administration of tetrahydrocortisone (pregnane-3α, 17α, 21-triol-11,20-dione)[2]. Substituting formic acid for acetic acid, as in system II, specifically increases the R_F values of the sulphates and diminishes tailing. This system is the most useful one so far developed for separating the three sulphates. System III separates the several glucuronosides from one another and from the sulphates, but does not separate completely the three members of the sulphate group. Fig. 1 illustrates the resolution of a mixture of conjugates 1, 2, 3, 4, 5 and 7 using system III. All three systems separate effectively conjugate 3 from conjugate 5 and, presumably, would separate other sulphates and glucuronosides having a common steroid moiety.

Table 1. R_F Values of Steroid Conjugates Chromatographed on Paper

Experiment 22A. Equilibration time, 14½ hr. at 29·7°–32·0° C. Running time, 5½ hr. at 28·5°–29·7° C.

Conjugate No.	Conjugate Identity	Chromatographic system I	II	III
1	β-Cortolone monoglucuronoside (crude)	0·14	0·16	0·08
2	Tetrahydrocortisone monoglucuronoside	0·39	0·42	0·13
3	Dehydroisoandrosterone glucuronoside	0·78	0·78	0·21
4	Pregnanediol monoglucuronoside	0·81	0·82	0·27
5	Sodium dehydroisoandrosterone sulphate	0·25	0·34	0·42
6	Sodium androsterone sulphate	0·38	0·47	0·45
7	Sodium pregnenolone sulphate	0·40	0·52	0·52

System I: *n*-Butyl acetate – *n*-butanol – 10 per cent acetic acid (80 : 20 : 100).
System II: *n*-Butyl acetate – *n*-butanol – 10 per cent formic acid (80 : 20 : 100).
System III: *n*-Butyl acetate – methanol – 0·1 *M* sodium barbital buffer in 50 per cent aqueous methanol, pH 8·2 (150 : 50 : 50) (monophasic).

Fig. 1. Resolution of a mixture (*M*, above) of conjugates 1, 2, 3, 4, 5 and 7 using system III. Running time, 5½ hr. at 30·5°–32·5° C. *S.L.* designates starting line and *S.F.* solvent front

We wish to thank Dr. Constance deCourcy for her advice and suggestions, and Dr. Seymour Lieberman for supplying the dehydroisoandrosterone glucuronoside used in these experiments.

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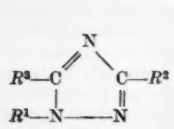
Inhibition of Cholinesterases by 1 : 2 : 4-Triazoles

It has been repeatedly observed in my laboratory that workers, including non-smokers, manipulating 1 : 2 : 4-triazoles develop symptoms of light nicotine or physostigmine poisoning from time to time. Subsequent experiments have shown that some simple water-soluble 1 : 2 : 4-triazoles may act as inhibitors of cholinesterase activity.

Fresh brains of sheep or rabbit homogenized in 0·025 *M* sodium bicarbonate were used as sources of cholinesterase. Sheep brains were satisfactory, but experiments with rabbit brains could not be satisfactorily duplicated. The inhibitors tested were 3 : 5-dimethyl (I)-, 1 : 3 : 5-trimethyl (II)-, 3 : 5-dimethyl-1-phenyl (III)-, 3-ethyl-5-methyl-1-phenyl (IV)- and 5-ethyl-3-methyl-1-phenyl (V)-1 : 2 : 4-triazoles.



	R^1	R^2	R^3
I:	H	Me	Me
II:	Me	Me	Me
III:	Ph	Me	Me
IV:	Ph	Et	Me
V:	Ph	Me	Et

The cholinesterase activity was determined by the manometric method[1], using acetylcholine, acetyl-β-methylcholine and benzoylcholine chlorides as substrates. In all experiments a time-effect was noted: after an initial rise, the pressure decreased to a minimum after 10–20 min., after which the usual rise was observed, occasionally with slight fluctuation. A second 'wave' (usually after 60 min. or more) was observed when using rabbit brain with or without inhibiting triazoles, or sheep brain with (I) or (II) as inhibitors. Fluctuation of temperature, lack of saturation of the tested mixtures with carbon dioxide or insufficient equilibration were excluded as the causes of this phenomenon.

Triazoles (III), (IV) and (V) had the same effects; most experiments were carried out with (III), which was readily available[2]. The nature of the inhibition was ascertained by plotting inverse rates of carbon dioxide evolution against inverse substrate concentrations. Specific cholinesterase is competitively inhibited by (III) for substrate concentrations of 1–30 mgm. acetyl-β-methylcholine / 100 ml. and triazole/substrate ratios in the range of 0·01–0·05. At lower concentrations of triazole there is no significant effect; at higher concentrations the enzyme is slightly activated. In a similar range of concentrations of benzoylcholine and triazole/substrate ratios, (III) activates the unspecific cholinesterase; inactivation occurs at higher triazole concentrations. With acetylcholine as substrate the results were not consistent. In general, lower concentrations of triazole appear to activate, and higher concentrations inactivate, the enzyme system. As the cholinesterase activity of sheep brain is largely due to the specific cholinesterase, it is evident that a factor other than the specific and unspecific cholinesterases is involved in this case. The nature of this factor and the reason for the waves of cholinesterase activity in the stated cases are subjects of further studies.

I wish to thank students of my Department, particularly Mr. R. Naylor and Mr. P. W. Smith, for their assistance in checking some of the results.

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Double Reduction at the Rosy, or Pink, Locus in *Lythrum salicaria*

It is one of the peculiarities of tetrasomic inheritance, such as we have been investigating for some years past[1] in the purple loosestrife, *Lythrum salicaria*, that, for any two loci in homologous chromosomes, there are a large number of possible genotypes heterogenic at both loci, and therefore capable of throwing light on the process of genetic recombination. With only two alleles available at each locus, there are indeed nineteen such genotypes, and with the linked loci for short style and for pink, or rosy, flower colour, most of these have been obtained; although the six genotypes triplex for the dominant Short gene have been inaccessible, owing to the illegitimacy of Short by Short matings.

For some years the only genotypes for which any large number of second backcross progenies had been scored were bisimplex coupling, *RS/rs/rs/rs*, and bisimplex repulsion, *Rs/rS/rs/rs*. About 1½ per cent of these appeared to come from gametes with two dominant genes, *R*, so indicating[2] about 6 per cent double reduction at the *R* locus. The percentage, however, was small, and in consequence a small proportion of alien pollen carrying the *R* gene could have seriously vitiated the estimated frequency. At the Short locus, for which the corresponding estimate was about 2½ per cent, the danger of similar contamination is obviated by the bar to illegitimate pollination.

A few years ago, therefore, preparations were made for a direct test of double reduction at the Rosy locus by preparing triplex plants *rS/Rs/Rs/Rs*, and in 1954 progenies amounting to 2,057 plants were grown, of which one only proved to be rosy, showing that the previous estimate was much too high. The new estimate would be 0·2 per cent, if the exceptional plant was accepted as genuinely from the same seed parent as the others, and, as any exception so rare as this is necessarily suspect, the true frequency might be even less.

That the parents of these 2,000 plants were certainly triplex at the Rosy locus has been demonstrated this year, 1955, by growing progenies of a hundred each from a second backcross of sixteen purple Short plants from last year. If the parents were of the genotype presumed, the expectation would be about six duplex, *RS/Rs/rs/rs*, and ten simplex in repulsion, *Rs/rS/rs/rs*. These were the only two genotypes recognized; there were in fact four and eleven respectively, one progeny being aberrant. The parents were evidently triplex, and the very low frequency of double reduction at the Rosy locus is confirmed.

The case illustrates well the efficacy of employing a second backcross for tetrasomic analysis. With the co-operation of Dr. O. H. Frankel at Canberra and Prof. H. N. Barber at Hobart, it is now hoped that the difficulties of obtaining tetraploids triplex at the Short locus also may be overcome in a few years.

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Monœcy and Incompatibility

It is customary when classifying breeding systems in Angiosperms to make a clear distinction between three main mechanisms promoting outbreeding. These are incompatibility in hermaphrodites, and separation of the sexes on the same plant (monœcy) or on different plants (diœcy). With incompatibility and diœcy outcrossing is obligatory. On the othe hand, separation of the sexes on monœcious plants merely decreases the probability of self-fertilization, although this may be further avoided by differences in time of maturity of the two types of flower.

Clearly, however, wherever the sexes mature together on a monœcious plant, an incompatibility system could be of distinct advantage. This possibility

is not discussed in recent articles on incompatibility[1,2]. The following examples which I have found recorded may serve to focus attention on this matter.

Cross- and self-incompatibility were found in *Euphorbia cyparissias* by Muenscher[3], and it was noted by East[4] that "this experiment is the first to establish that physiological incompatibility may exist in a monoecious species". Clapper[5] showed that the Japanese chestnut (*Castanea crinita*) and the Chinese chestnut (*C. mollissima*) only rarely set fruit after self-pollination. From a review of pollination experiments with *Hevea braziliensis* (Euphorbiaceae)[6] it appears that self- and cross-incompatibility occur, and that there may be reciprocal differences in seed-setting. Whether this is an example of sporophytic control of incompatibility remains to be seen.

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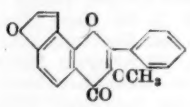
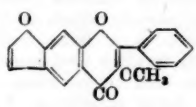
New Flavones from *Pongamia pinnata* (L.) Merr.: Identification of Compound *D*

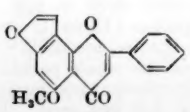
Two new furano-flavones (compounds *C* and *D*) were reported by Row[1] from the root bark of *Pongamia pinnata* (L.) Merr., besides karanjin (I)[2] and its methylene dioxy derivative, named pongapin. From a study of the alkaline degradation and other reactions, they were regarded as isomeric with pongapin and karanjin respectively.

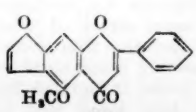
In an effort to identify these compounds, the simple linear isomer of karanjin, 3-methoxy-furano-7 : 6 : 2′ : 3′-flavone (II), was synthesized by Pavanaram and Row[2]; but it was not identical with compound *D*.

A reconsideration of the reactions of the compounds *C* and *D* revealed that they could be furano-flavones unsubstituted in the third position, since no ketone could be isolated from the products of alkaline hydrolysis of these compounds. To test this possibility, 5-methoxy-furano-7 : 8 : 2′ : 3′-flavone (III) was obtained synthetically from the O-benzoyl derivative of 4-hydroxy-5-acetyl-6-methoxy coumarone[3] by an application of Baker–Venkataraman migration[4] (potassium hydroxide – pyridine method). The furano-flavone (III) (melting point 180°; thin, fragile, narrow needles, from ethyl alcohol) depressed the melting point of compound *D* (melting point 177–79°) considerably (130–45°), thus establishing their non-identity.


(I)


(II)


(III)


(IV)

The linear 5-methoxy-furano-7 : 6 : 2′ : 3′-flavone (IV) was also prepared from the benzoate of visnaginone by the Baker–Venkataraman method (using potassium hydroxide – pyridine). The furano-flavone (IV) (melting point 181–82°; broad rectangular prisms with a tendency to taper at one end) did not depress the melting point of compound *D* and was absolutely identical in its reactions.

The synthesis of 3″ : 4″-methylene dioxy derivative of the furano-flavone (III) was accomplished similarly. Its melting point was 263–64° and was different from compound *C* (melting point 232–33°). The synthesis of the isomeric 3″ : 4″-methylene dioxy derivative of the other furano-flavone (IV) is in progress.

With the identification of compound *D*, a new group of furano-flavones unsubstituted in the third position comes to light. Unlike karanjin (I), it belongs to the linear type. In this connexion, it is interesting to note that the only other naturally occurring furano-flavone so far reported is the unsubstituted furano-7 : 8 : 2′ : 3′-flavone (lanceolatin *B*), isolated from the roots of *Tephrosia lanceolata* Grab[4].

We are indebted to Prof. Alexander Schönberg, of the University of Cairo, for a gift of visnagin used in this investigation. We learn from him that the furano-flavone (IV) was also recently synthesized in his laboratories from visnaginone. Full details of the present investigation will be published elsewhere.

S. K. Pavanaram
L. Ramachandra Row

Chemistry Department,
Andhra University,
Waltair, S. India.

July 13.

[1] Row, *Aust. J. Sci. Res.*, **5A**, 754 (1952).
[2] Pavanaram and Row, *J. Sci. Indust. Res.* (*India*), **14B**, 157 (1955).
[3] Phillips, Robertson and Whalley, *J. Chem. Soc.*, 4953 (1952).
[4] Rangaswami and Sastry, *Curr. Sci.*, **24**, 13 (1955).

Two Indo-Pacific Fishes, *Dasyatis uarnak* and *Upeneus moluccensis*, in the Eastern Mediterranean

During 1954, several specimens of *Dasyatis uarnak* (Forskål) were observed along the Mediterranean coast of Israel. They were caught by trawlers in depths of 15–40 fathoms. The captured fishes were usually big, with the disk often more than 100 cm. in diameter. One comparatively small specimen is preserved in the collection of the Sea Fisheries Research Station, Haifa. Its dimensions are: length of disk 440 mm., width of disk 470 mm., length of tail 1,215 mm.

The fish has not been recorded hitherto from the Mediterranean. It seems to be a common fish in the Indo-Pacific, and has been reported from the Suez Canal[1], through which the species has apparently passed to the Levant.

Upeneus moluccensis (Bleeker) is now common enough in the eastern Mediterranean to be of economic importance and has been mentioned several times under a wrong identification as *Mulloidichthys auriflamma* (Forskål)[2]. A careful examination of an extensive material from the Israeli coast and from Mersin, Turkey, revealed that all the fish belong to a single species, *U. moluccensis*. I have been able to

compare the specimens from Israel with four paratypes of *U. moluccensis* lent me from the collection of the Rijksmuseum van Natuurlijke Historie, Leyden, and I can find no differences between them. Vomerine teeth, stated to characterize the genus *Upeneus*[3], are absent from both samples in specimens more than 65 mm. long, and this has led authors[3] to place it in another genus, in spite of the fact that the presence of palatine teeth should exclude it from *Mulloidichthys*.

Unlike other Indo-Pacific species recently recognized in the Mediterranean, *U. moluccensis* has never been recorded from the Red Sea; but if, as seems probable, it came through the Suez Canal, it must surely occur there.

A systematic analysis of these species will be published elsewhere. I am indebted to Dr. E. Trewavas for reading this manuscript and to Mr. N. B. Marshall and Dr. M. Boeseman for their help in securing a loan of the paratypes of *U. moluccensis*.

A. Ben-Tuvia
(British Council Scholar)
British Museum (Natural History),
London, S.W.7.
July 26.

[1] Tillier, J. B., *Mém. Soc. Zool. France*, **15**, 279 (1902).
[2] Haas, G., and Steinitz, H., *Nature*, **160**, 28 (1947). Laskaridis, K., *Prak. Hellen. Hydrob. Inst.*, **2**, 103 (1948). Tortonese, E., *Boll. di Zool.*, **22**, 73 (1953). Ben-Tuvia, A., *Bull. Sea Fish. Res. Stat.*, **8**, 25 (1953).
[3] Lachner, E. A., *Proc. U.S. Nat. Mus.*, **103**, 497 (1954).

Aeration of Coliform Cultures

Periodically, cultures of coliform organisms in simple synthetic medium (glucose–phosphate–ammonium salt) have failed to grow when aerated in this laboratory, contrary to experience in other towns. This culminated in a few weeks when such cultures refused to grow at all, so that the possible presence of poisons in the air was suspected. Consequently the air intake of the compressor was placed outside the laboratory buildings. The phenomenon persisted during the daylight hours but was eliminated at night time.

Two points now emerged: at the time, this area was suffering excessive and almost continuous rainfall, and the air intake was just above a mass of actively growing plants. This suggested that the trouble might be due to carbon dioxide deficiency in the atmosphere, which was being rectified by the metabolism of the plants when it was dark. Chemical investigation showed that in fact there was about five times as much carbon dioxide in this air at night as during the day, and about twice as much as in air taken from the laboratory during the day.

Various workers have noted the need for carbon dioxide by these organisms, probably to permit the formation of the C_4 dicarboxylic acids[1–5]. The addition of chemically prepared carbon dioxide or of extremely small quantities of succinic acid eliminated the phenomenon. From the work of Dagley and Hinshelwood[2], it can be calculated that a very small gas flame produces sufficient carbon dioxide to meet the requirements of a considerable number of cultures.

The air intake was now transferred to the space below a gas-operated incubator to ensure a sufficiency of carbon dioxide. The gas sucked in was purified by spraying as an oil–air emulsion, filtering and then passing through an efficient washing system filled with strong chromic acid. This removed dust, alkaline vapours and oxidized volatile substances. The gas was washed efficiently with bicarbonate solution to absorb all acid vapours and replace them with carbon dioxide. It then passed through a bacteriological filter. The use of this air has eliminated the trouble completely.

The importance of adequate carbon dioxide has since been repeatedly emphasized: many phenomena being studied have been much more reproducible and in many cases the intrusion of lag phenomena eliminated. Such an example is the effect of phenol in low concentration on one organism. Originally there was a progressive increase in observable lag and of the mean generation time with increase of phenol concentration; but with the new air supply no lag phenomena are observed.

There may be many instances elsewhere where fluctuating carbon dioxide content of the atmosphere and/or a bare average sufficiency are producing artefacts: here the problem became acute because of a prevailing wind blowing from the open sea past an extremely well-ventilated coastal laboratory.

G. A. Morrison
D. E. Griffiths
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Dairy Buildings,
Biochemistry Section,
University College,
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Oct. 3.

[1] Dagley, S., Dawes, E. A., and Morrison, G. A., *Nature*, **163**, 532 (1949).
[2] Dagley, S., and Hinshelwood, C. N., *J. Chem. Soc.*, 1930 (1938).
[3] Gladstone, G. P., Fildes, P., and Richardson, G. N., *Brit. J. Exp. Path.*, **16**, 335 (1935).
[4] Elsden, S. R., *Biochem. J.*, **32**, 187 (1939).
[5] Wood, H. G., Werkman, C. H., Hemingway, A., and Nier, A. O., *J. Biol. Chem.*, **135**, 789 (1940); **139**, 365 (1941).

Resistance to Lymphomatosis in the Fowl in Relation to Reproduction

Over the past twenty years, the feasibility of breeding strains of fowls in which mortality from lymphomatosis is reduced to negligible levels has been demonstrated[1,2]. Many poultry breeders are now developing resistant strains. If families resistant to this disease do not hatch as well as families that are susceptible, as Coles and Underwood have stated[3], the desirability of attempting to develop resistant stock may seem dubious. Accordingly, we have examined our records for the past six years for evidence of any such relationship.

In so doing, we have compared (as did Coles and Underwood) families of full sisters showing one or more deaths from lymphomatosis with families in which no females died of that disease during our test period, which is from 42 to 500 days of age. Since, in a later exposition of the same data[4], both fertility and hatchability of resistant families were said to be lower than in susceptible families, we have considered both these important factors which influence the efficiency of reproduction.

Records for matings of proved sires in our *K*-resistant strain of White Leghorns (Table 1) show the variation from year to year that is inevitable with relatively small numbers. Over the whole period of six years, in families free of lymphomatosis, fertility (of their dams) was lower by 1·9 per cent; but

hatchability was higher by 2·0 per cent, than in families losing one or more birds from that disease. Neither difference is significant. These data show no consistent relationship between resistance to lymphomatosis and efficiency of reproduction.

It is probable that this finding differs from that of Coles and Underwood because the data in Table 1 are restricted to dams' families comprising not less than ten tested daughters. Altogether there were 2,685 such daughters, and in these the incidence of fatal lymphomatosis during the test period was 2·7 per cent. Among 725 females in the 44 dams' families that had one or more cases, the incidence was 9·8 per cent. With such low frequencies, small families have much less chance to show a single case of lymphomatosis than large ones. Since the smaller families result from poor reproduction and the larger ones from good reproduction, any division of the population into families that have either (*a*) no lymphomatosis or (*b*) one or more cases of it must throw most of the poor reproducers into the former class and the better reproducers into the latter one. Thus, in the birds considered by Coles and Underwood[3] the average size of family ranged in four years from 7·3 to 10·8 for those free of lymphomatosis, but was 9·0 to 15·2 for those showing one or more cases[4]. Under such conditions, even if the incidence of lymphomatosis were as high as 15 or 20 per cent, any apparent relationship between susceptibility to the disease and efficient reproduction is completely spurious.

Much of the error in such an analysis is removed by restricting the data to larger families. In those considered in Table 1, the average number of daughters per dam was 16·4 in families showing lymphomatosis and 15·8 in families that did not. All the error can be eliminated by using a better type of analysis. The susceptibility of any family or group of birds to any disease is best measured, not by the presence or absence of a single case of that disease, but by the proportion of susceptible birds, that is, the incidence of the disease. Thus, in two groups of 100 birds each, one comprising 20 small families and the other five large ones, the incidence of lymphomatosis should, *ceteris paribus* be about the same.

Among families from proved sires in our *K*-resistant White Leghorns from 1949 until 1954 there were seven in which no daughters died of lymphomatosis. In each of the remaining nineteen sire families, the dams were separated into two classes

Table 1. Reproduction of Hens producing Families With or Without Subsequent Lymphomatosis

Year	Dams	Eggs incubated	Fertile (per cent)	Fertile eggs hatched (per cent)	Daughters tested
	A. Families with one or more deaths from lymphomatosis				
1949	15	579	97	88	217
1950	2	81	100	95	24
1951	11	441	89	86	160
1952	12	646	92	85	253
1953	1	40	100	93	25
1954	3	104	98	91	46
Averages			93·4	87·1	
	B. Families with no deaths from lymphomatosis				
1949	10	381	94	91	157
1950	19	748	95	89	262
1951	29	1,143	90	91	444
1952	14	651	80	89	221
1953	27	1,100	92	86	397
1954	31	1,160	97	89	479
Averages			91·5	89·1	

Table 2

	Dams	Daughters	Lymphomatosis (per cent)
Hatchability above average	110	1,595	3·7
Hatchability below average	73	798	3·4

as having hatchability either (*a*) above average for the pen, or (*b*) below that average. The incidence of lymphomatosis in the pullets hatched from these two groups was as shown in Table 2.

Dams below average are fewer than those above because, when hatchability is high, the distribution of dams with respect to it is skewed, and most hens below average depress that figure more than it can be raised by individual hens above it. The average numbers of daughters per dam in the two groups were 14·5 and 10·9, but, since the smaller families are grouped together, bias from that source is eliminated. Actually the two groups are not strictly comparable. The hens with hatchability below average included most of the oldest proved dams, which produced highly resistant daughters but (because of old age) fewer of them. Conversely, the hens above average included some not previously progeny-tested, but considered (from viability of their sisters) to be worth trying. These birds, being younger, reproduced well, but in some cases yielded rather susceptible families.

In spite of this, the two groups compared do not differ significantly in the incidence of lymphomatosis. It is clear from these data, as from those in Table 1, that resistance and susceptibility to lymphomatosis in the progeny are not related to the efficiency of reproduction in the dam.

F. B. Hutt
R. K. Cole

Department of Poultry Husbandry,
New York State College of Agriculture,
Cornell University,
Ithaca, New York.

[1] Hutt, F. B., and Cole, R. K., *Science*, **117**, 695 (1953).
[2] Hutt, F. B., and Cole, R. K., Sect. Papers Tenth World's Poultry Congr. (Edin.), 197 (1954).
[3] Coles, R., and Underwood, J. R., *Nature*, **173**, 887 (1954).
[4] Coles, R., *Poultry Sci.*, **34**, 312 (1955).

Relationship between Blood Factors *P* and *Q*

The relationship between blood factors *P* and *Q* has been investigated by comparing an anti-*Q* agglutinin (Japanese) with several anti-*P* of human and animal origin.

The anti-*Q* has been used for agglutination tests only, while the *P* factor has been determined by absorption as well as by agglutination.

A total of 224 samples were tested, giving the following results:

	Q+	*Q*−	Total
P+	113	0	113
P−	0	111	111
Total	113	111	224

Cross-absorption experiments have not been carried out, as no discrepancies have been found.

Furthermore, the receptor strength of each positive sample was estimated by the strength of agglutination. In this respect, too, the reactions of anti-*Q* were found to parallel closely the reactions of anti-*P*.

Further details will be published elsewhere.

In our opinion, the result of the present investigation—until further irrefutable proof of the separate identity of the properties is found—justifies the assumption that *P* and *Q* are identical.

Our thanks are due to Prof. Tanemoto Furuhata, Tokyo, for a gift of anti-*Q*.

K. Henningsen
Tyge Jacobsen
University Institute of Legal Medicine,
Copenhagen, Denmark. July 13.

A Caliper for measuring Photographs, X-Rays and Drawings

There is at present no instrument on the market suitable for measuring distances in photographs, X-rays or drawings both accurately and in considerable numbers. Our particular problem was to measure various dimensions of the human figure on 12 in. × 10 in. pictures of subjects photographed in the nude for studies of body-build. The measurements had to be accurate to 0·1 mm., and a large number of them had to be recorded. In this technique, known as photogrammetric anthropometry, needle-pointed calipers are used, so as to locate the precise point at which the edge of the body shades into the white background of the picture. Some form of enlargement of the scale of measurement other than a vernier, which is awkward to read and thus gives rise to too many reading errors, was clearly desirable. We first used calipers based on a scissors principle, with a magnification of scale of about × 5 due to the needle-pointed arms being shorter than the arms carrying the reading scale[1]. However, these proved unsatisfactory in practice due to the scale being on the chord rather than the arc of the opening circle, and because adjustment to remedy this varied from one instrument to another and was not entirely reliable.

A straight-bar design appeared to be better, and eventually the question of how to achieve the required scale enlargement was solved by the use of a dial gauge. The new instrument, made by British Indicators, Ltd., Sutton Road, St. Albans, Herts, is illustrated in Fig. 1. It rests flat on the photograph with the needle-tips adjusted so as just to clear the surface until tilted a fraction downward. The dial reads a total of 10 mm. in 0·1 mm. divisions and is linked to the right-hand needle point, which is moved by operating the thumbscrew at the far right-hand end. The left-hand needle point can be fixed at 1 cm. intervals up to 15 cm. by releasing the trigger seen underneath the left-hand bar, and moving the bar along until the desired figure appears in the round window at its right-hand end. This provides the coarse adjustment mechanism and enables the instrument to read in divisions of 0·1 mm. from zero up to as much as 15 cm. There is play of about 0·1 mm. in the thumbscrew mechanism, but this can be practically entirely obviated by arranging always to rack the dial in the same direction before taking the final reading.

We have recently found this instrument useful for measuring the relative amounts of bone, muscle and fat along given diameters in X-rays of the legs and arms (see ref. 2), and in measuring the growth of epiphyses in serial X-rays of growing children. However, it is so much less tedious in operation than conventional dividers that it seems likely to be of use to research workers and engineers in a variety of fields.

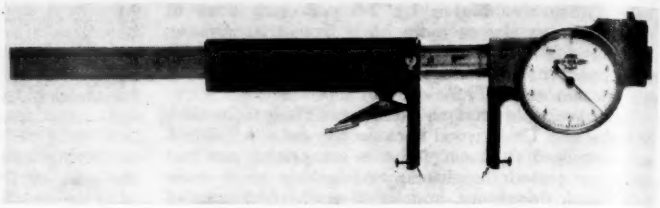

Fig. 1

J. M. Tanner
R. H. Whitehouse
Sherrington School of Physiology,
St. Thomas's Hospital,
London, S.E.1. July 27.

[1] Tanner, J. M., *Lancet*, **1**, 574 (1951).
[2] Tanner, J. M., "Growth at Adolescence" (Blackwell Sci. Pub., Oxford, 1955).

Removal of Mineral Nutrients from Tree Crowns by Rain

In 1951, C. O. Tamm[1] gave figures for the mineral nutrient composition of rain-water collected under three species of forest trees. M. G. Mes[2] has since published experimental work on the loss of phosphorus and other mineral elements from living leaves due to the influence of rain.

This communication reports the composition of rain-water collected under a thirty-year old plantation of *Pinus radiata* D. Don in Whakarewarewa Forest, Rotorua Conservancy.

The supply of nutrients to the soil in rain-water is compared with the return contained in the litter-fall from the stand. The results in Table 1 cover the period November 26, 1954–June 2, 1955.

Table 1. Nutrient Content of Rain-water and Litter collected beneath *P. radiata*

	Rain-fall (cm.)	Litter-fall (gm./m.²)	Nutrient return to soil (m. equiv./m.²)				
			Ca	Mg	K	Na	P
Rain-water 30 yd. from trees	68·7	—	1·3	1·4	2·2	23·4	—
Rain-water beneath trees	42·0	—	4·7	12·6	21·5	81·4	4·9
Litter beneath trees	—	252	61·6	21·2	16·5	10·4	24·6

It seems that when considering the return of mineral nutrients to the soil under *P. radiata*, both litter-fall and rainfall must be taken into consideration, since in the cases of potassium and sodium a large proportion of the total return to the soil is contained in the rainfall.

A fuller account of this work will be published at a later date.

G. M. Will
Forest Research Institute,
Whakarewarewa,
Rotorua, New Zealand.
July 12.

[1] Tamm, C. O., *Physiol. Plant.*, **4**, 184 (1951).
[2] Mes, M. G., *South Afr. J. Sci.*, **50**, 167 (1954).

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, December 19

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Prof. S. W. Wooldridge and Miss E. M. J. Campbell: "Between Two Forests".

INSTITUTE OF METAL FINISHING (at the Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Dr. A. E. Davies: "Tin-Cadmium Alloy Plating".

Tuesday, December 20

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. N. A. de Bruyne: "Recent Advances in Aircraft Adhesives".

Wednesday, December 21

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Mr. C. H. B. Priestley: "Free and Forced Convection in the Atmosphere Near the Ground"; Mr. R. Anderson, Mr. B. W. Boville and Mr. D. E. McClellan: "An Operational Frontal Contour Analysis Model".*

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Prof. H. Wold: "Explanatory Approaches with Observational Data (A Review of Ends and Means)".

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Dr. J. M. Rowson: "Comfrey (*Symphytum Officinale* L.) Root: Its Anatomy and its Detection in Admixture with Chicory in Dandelion Coffee".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (male, single, with a university degree or diploma in horticulture and a sound knowledge of practical horticulture) IN HORTICULTURE—The Principal Agricultural Officer, Lancashire County Institute of Agriculture, Hutton, near Preston (December 24).

SCIENTIFIC OFFICERS (with a first- or second-class honours degree in engineering, physics or mathematics or equivalent qualifications), and ASSISTANT EXPERIMENTAL OFFICERS (with at least G.C.E. (advanced level) in mathematics or equivalent qualifications), IN THE MECHANICAL ENGINEERING RESEARCH LABORATORY (D.S.I.R.), East Kilbride, Glasgow, for work on fluid flow, heat-transfer, lubrication, materials and mechanisms—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.886/5A (December 24).

ASSISTANT (registered veterinary surgeon) IN THE DEPARTMENT OF VETERINARY ANATOMY, Royal (Dick) School of Veterinary Studies—The Secretary, The University, Edinburgh (December 28).

ANIMAL PATHOLOGIST (with a veterinary qualification) to take charge of the Department of Animal Pathology, Zoological Gardens, Regent's Park—The Director and Permanent Secretary, Zoological Society of London, Regent's Park, London, N.W.1 (December 31).

ASSISTANT LECTURER IN PSYCHOLOGY, with special reference to industrial and occupational psychology—The Registrar, The University, Hull (December 31).

LECTURER IN THE DEPARTMENT OF PATHOLOGY—The Secretary, The University, Edinburgh (December 31).

LECTURER (with special qualifications in inorganic chemistry, including experience in teaching from elementary level upwards) IN CHEMISTRY in St. Salvator's College—Joint Clerk to the University Court, The University, St. Andrews (December 31).

PHYSIOLOGIST (with a university degree, preferably with physiology as a main subject, and between the ages of 21 and 28 years) in the General Post Office, to undertake field and laboratory studies on problems relating to factors affecting individual performance, and to work under the general direction of the Consultant Physiologist to the Post Office in London—P.O. Engineering Department (St1/4), Alder House, Aldersgate Street, London, E.C.1 (December 31).

MAY AND BAKER RESEARCH FELLOW (graduate in chemistry) to undertake research work under the direction of Prof. R. L. Wain in organic chemistry in the fields of growth regulating substances or systematic fungicides—The Registrar, Wye College, near Ashford, Kent (January 7).

PHYSICIST (with a first- or second-class honours degree and preferably have worked for at least two years in a radiotherapy department) to work in the Physics Department, but with special duties in the Radiotherapy Department—The Superintendent, Guy's Hospital, London, S.E.1 (January 7).

BIOCHEMIST (non-medical), Scientific Officer (Senior grade), for duties at the Central Laboratory, 51 Lisburn Road, Belfast—The Secretary, Northern Ireland Hospitals Authority, Victory Buildings, 44–46 Queen Street, Belfast (January 13).

RESEARCH FELLOW IN MATHEMATICAL PHYSICS at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, January 15).

VETERINARY RESEARCH OFFICER (with a veterinary qualification and experience in the organization and execution of field experiments, particularly with farm animals), to take an active part in research work, and a BIOCHEMIST (with a veterinary qualification or a good degree in chemistry or biochemistry, and experience in the field of animal nutrition and disease), to organize and initiate research, at the Animal Health Trust Farm Livestock Research Station, Stock, Essex—The Scientific Director, The Animal Health Trust, 14 Ashley Place, Westminster, London, S.W.1 (January 17).

SENIOR LECTURER OR LECTURER IN CLINICAL PATHOLOGY, LECTURER IN MORBID ANATOMY, and a LECTURER IN BACTERIOLOGY in the Department of Pathology, University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (January 30).

CHAIR OF EXPERIMENTAL PHYSICS—The Registrar, The University, Liverpool (January 31).

READER OR SENIOR LECTURER IN THE THEORY OF COMPUTING IN THE DEPARTMENT OF MATHEMATICS—The Registrar, The University, Manchester 13 (January 31).

RESEARCH STUDENTS/FELLOWS IN THE SCHOOL OF PHYSICS—The Registrar, The University, Sydney, Australia (January 31).

LECTURER IN ASTRONOMY—The Registrar, The University, Manchester (February 28).

LECTURER (with special qualifications in stratigraphy) IN GEOLOGY in St. Salvator's College—Joint Clerk to the University Court, The University, St. Andrews (February 29).

PROFESSOR OF AGRICULTURE at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 15).

AGRONOMIST, Senior Scientific Officer or Scientific Officer grade (with at least a second-class honours degree, and not less than two years appropriate postgraduate experience, and some experience of cocoa research or cocoa production), at the West African Cocoa Research Institute, Gold Coast, to design and conduct field experiments on cocoa, including yield, spacing, establishment, manurial, variety and other trials and to conduct experiments on fermentation and quality of cocoa—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting Ref. No. BCD.197/200/05.

ASSISTANT, Grade A (with a good degree) IN MATHEMATICS—Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham.

ASSISTANT, Grade B (graduate in physics and preferably with experience in teaching and industry and a knowledge of some branch of applied physics), IN THE PHYSICS DEPARTMENT, Sunderland Technical College—The Director of Education, 15 John Street, Sunderland.

BIOCHEMIST or CHEMIST (with experience in routine biochemical techniques)—The Director, Department for Research in Industrial Medicine, London Hospital, E.1.

CHARTERED LIBRARIAN (with previous experience in a scientific or technical library)—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

CHEMIST or PHYSICIST, Experimental Officer or Assistant Experimental Officer grade (preferably with a degree or H.N.C. in chemistry or physics, or at least H.S.C. (science) or equivalent), at a Ministry of Supply Experimental Establishment, Christchurch, Hants, to plan and carry out tests on properties of soils in connexion with their use for roads and airfields, and for investigation of soil stabilization techniques, etc.—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.442/5A/ED.

ELECTRONICS AND WORKSHOP TECHNICIAN (with some practical experience in the maintenance of electronic or allied apparatus)—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

ENTOMOLOGIST (with a university degree in zoology (major subject being entomology), and preferably with postgraduate experience in mosquito control), in the Medical Department, H.M. Overseas Civil Service, Tanganyika, for field and laboratory entomological work with special reference to mosquitoes, and for the initiation and management of surveys and control work in urban centres and airports—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. No. BCD.117/8/024.

FOREST UTILIZATION OFFICER (with a university degree in either forestry or engineering, with postgraduate experience in forest engineering and/or in timber utilization) in Northern Rhodesia, to conduct research into the use of indigenous hardwood timbers by the Rhodesian copper mining industry, with particular attention to fungal decay and the preservative treatment of underground mining timbers, to assist sawmilling and logging firms on improving methods of logging, etc., and to assist in the development of wood-using industries—The Director of Recruitment, Colonial Office, Sanctuary Building, Great Smith Street, London, S.W.1, quoting BCD.61/3/02.

LECTURER IN THE DEPARTMENT OF ELECTRICAL ENGINEERING, Technical College, Bradford—The Director of Education, Town Hall, Bradford.

LECTURER (preferably with qualifications in electrical engineering) IN ENGINEERING in the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1.

MATHEMATICIAN AND STATISTICIAN (with a degree or equivalent qualification, and preferably some knowledge of economics) IN THE OPERATIONAL RESEARCH SECTION of the Association in London, to continue a study of the productivity of steel rolling processes—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "O.R.3".

PHYSICIST (with a first- or second-class honours degree in physics, and preferably with some research experience in optics or electronics) at the Royal Aircraft Establishment, Farnborough, for problems of photography from high speed, high altitude aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.450/5A/OB.

PHYSICIST (with a university degree in science and not less than three years experience as a physicist in a radiotherapy unit) in Salisbury Hospital, Rhodesia—The Secretary, Federation of Rhodesia and Nyasaland, Rhodesia House, 429 Strand, London, W.C.2.

PRINCIPAL BOTANIST, Principal or Senior Principal Scientific Officer grade (over 31, with at least a second-class honours degree in botany, with postgraduate training in cytology, genetics or plant physiology, and a good record of achievement in one or more of these branches, preferably in relation to tree crops), at the West African Cocoa Research Institute, Gold Coast, to organize, supervise, and take part

in the work of the Botany Division, including cytology, genetics, plant breeding, physiology and general botany, with special reference to cocoa and its allies—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting BCD.197/2c0/011.

Scientific Officer (with a first- or second-class honours degree or equivalent in physics or electrical engineering, and preferably with some electronics experience) at the Ministry of Supply Royal Aircraft Establishment, Aberporth, South Wales, for research and development on electronic instrumentation—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.451/5A/KA.

Senior Technician in the Department of Physiology, University College, Ibadan—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1.

Technical Assistant (preferably with experience of vacuum and high temperature equipment) in the General Physics Section of the Physics Department, to assist in research on metal physics problems associated with the solidification processes in metals and with mechanical properties generally—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting G.P.1.

Technician for research and general laboratory duties in the Botany Department, Dulwich, London, S.E.24, in the fields of biochemistry and microbiology—The Secretary, King's College, Strand, London, W.C.2 (Ref. 9491).

Technician in the Department of Anatomy, Kitchener School of Medicine, University College of Khartoum—The Secretary, Inter-University Council for Higher Education Overseas, 1 Gordon Square, London, W.C.1.

University Demonstrator (member of the Royal College of Veterinary Surgeons) in the Department of Veterinary Clinical Studies, University of Cambridge—The Secretary, Appointments Committee of the Faculty of Medicine, Department of Experimental Medicine, Tennis Court Road, Cambridge.

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